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DEPARTMENT OF AGRICULTURE, INSURANCE, STATISTICS AND HISTORY.

GEOLOGICAL SURVEY OF TEXAS.

JNO. E. HOLLINGSWORTH, Commissioner. E. T. DUMBLE, State Geologist.

BULLETIN NO. I.

ARTESIAN WATER

ON

THE LLANO ESTACADO.

BY

DR. GEORGE G. SHUMARD

REPORT AND ANALYSES

OF

TEXAS SUMACH (RHUS COPALLINA).

BY

GEORGE H. KALTEYER.

AUSTIN:
HENRY HUTCHINGS, STATE PRINTER
1892.

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LETTER OF TRANSMITTAL.

DEPARTMENT OF AGRICULTURE, INSURANCE, STATISTICS, AND HISTORY.
GEOLOGICAL SURVEY OF TEXAS.

AUSTIN, TEXAS, February 20, 1892.

Hon. J. E. Hollingsworth, Commissioner of Insurance, etc., Austin, Texas:

DEAR SIR—I transmit herewith for publication as Bulletin No. 1, two articles which relate to work done previous to the organization of the present Survey.

The first of these, entitled "Artesian Water on the Llano Estacado" was found among the papers of Dr. George G. Shumard which were loaned to the present Survey by his family. I have been unable to find it in print anywhere. Although a very brief statement, it contains facts which are very important in their bearing on the artesian water supply of Western Texas, and it is therefore put into this form in order that it may be available.

The second article, "Report and Analyses of Texas Sumach," by Geo. H. Kalteyer, is the result of work taken up by Mr. Kalteyer at the request of Hon. Jno. W. Glenn, State Geologist in 1874. The value of Texas sumach (and of mesquite also) in tanning was practically tested during the years 1861 to 1866, but this is the earliest experimental work with which I am acquainted which endeavors to show by careful analysis the actual and comparative value of the variety of sumach which occurs here in quantity.

Yours very truly,
E. T. DUMBLE,
State Geologist.

ARTESIAN WATER

ON THE

LLANO ESTACADO.

REPORT OF DR. G. G. SHUMARD TO CAPT. JOHN POPE.

ARTESIAN WATER ON THE LLANO ESTACADO.

REPORT OF DR. G. G. SHUMARD TO CAPT. JOHN POPE.

May 1st, 1856.

SIR—In obedience to your instructions of April 22nd, I have carefully reviewed my notes and sections taken between this point and the Guadalupe mountains, and made such additional geological examinations in this vicinity as I deemed necessary in order to determine the practicability of obtaining water by means of artesian wells at or near the point selected for the present experiment, and would respectfully submit the following as the result:

The region known as the Llano Estacado or Staked Plains, upon which the well is located, may be considered, geologically, as forming but a portion of a continuous slope which extends from near the eastern base of the Rocky Mountains east to within a short distance of the western borders of the settlements. This slope is composed of strata belonging principally to the upper portion of the Secondary period and presents generally geological conditions in the highest degree favorable for water by means of artesian wells. What these conditions are it is unnecessary for me at this time to state, inasmuch as the subject has already been fully discussed in your report of 1855. I will merely add that so far as they relate to the subject under consideration, the leading conclusions at which you had then arrived have been fully borne out by my subsequent examinations. But favorable as these general conditions are, there are nevertheless certain local exceptions which, wherever they occur, may greatly influence the success of experiments for water by means of artesian borings, and should on that account, whenever practicable, always be carefully avoided. Among these may be mentioned great local flexures or contortions of the strata and the occurrence of deep valleys of denudation. The former, as they are often accompanied by more or less rupture of the layers, may operate by either diverting or entirely arresting underground currents of water, while the latter, whenever they occur between the point of entrance, or source of supply, and that from which water is attempted to be obtained by artesian borings, must necessarily always tend to render the results of such experiments exceedingly doubtful.

The accompanying sections will show that the results of the present one may not be entirely uninfluenced by one or both of these causes.

Section No. 1 exhibits a deep valley of denudation which extends from near the southern extremity of the Guadalupe mountains east, through the distance of twenty-two miles, to the head of Delaware creek. Not taking into account the underlaying sandstone, portions

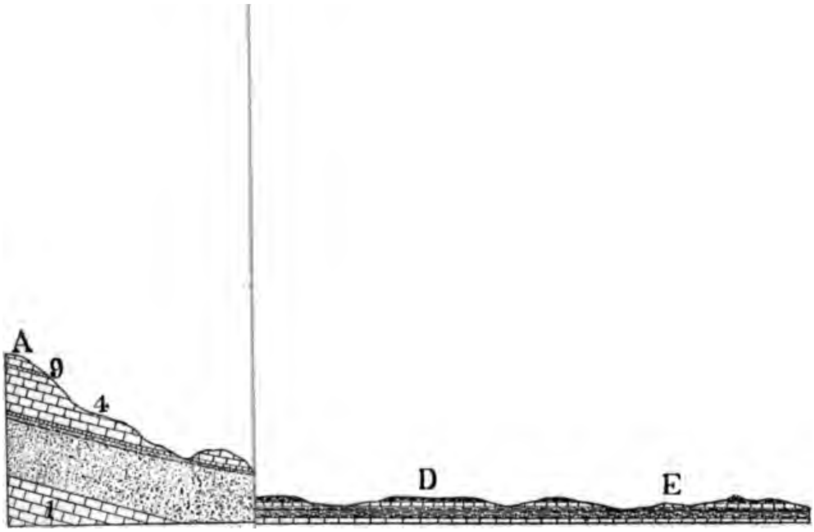
of which have also suffered largely in the same manner, the thickness of solid strata here removed by denudation cannot fall far short of one thousand feet. How far this valley extends north of the line of survey, I am at present unable to determine, never having had an opportunity of carrying my examinations in that direction, but inasmuch as we have certain evidence that the causes producing it have operated with much greater force south than immediately to the north of that line, it is possible that it may not extend sufficiently far in the latter direction to interfere with the success of the present experiment. But as it may prove to be otherwise, I am of the opinion that the probability of success would have been increased had the well been located ten or fifteen miles further north. As this opinion may be objected to on the ground that the edges of the strata are still exposed at the distance of twenty-two miles from the mountains, and may there serve as sufficient receptacles of atmospheric moisture, I would state that I have no positive evidence that the amount of rainfall is there sufficient to supply water at the distance of forty or fifty miles by means of artesian wells, but even admitting that such should be the case, it is evident that the supply thus obtained would be likely to be far less constant than when procured from the immediate vicinity of the mountains, where all the requisite meteorological conditions are supposed to exist.

Section No. 2 is taken from near the east bank of the Rio Pecos at a point situated about eight miles west of the well. Here we have the strongest evidence of disturbance, the strata being deeply folded, portions of their anticlinal axes denuded, and dipping in different directions at angles varying from forty-five to fifty degrees. These flexures have been traced from near the mouth of Delaware creek to within a short distance of our present camp; how far they extend in the opposite direction I am unable at this time to state, as satisfactory sections have been witnessed only in the immediate vicinity of the river, the geology of the country both to the east and west being obscured by thick deposits of much more recent origin.

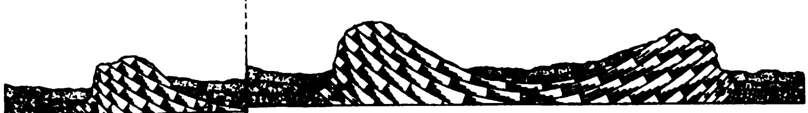
Inasmuch as this region of disturbance lays immediately to the west of the well, it may, even should its eastern limits not extend more than a mile or so from the Rio Pecos, tend to interfere with the present experiment, and furnishes an additional argument in favor of the selection of some other locality for testing the practicability of obtaining water by the means proposed on the Llano Estacado.

In conclusion, I would state it as my opinion, that should the present experiment prove successful, the result will be of additional value as tending to show that water may here be procured even under unfavorable circumstances; while on the contrary, should it prove otherwise, and a supply fail to be brought to the surface, such failure will be

no evidence that water cannot be obtained upon the Llano Estacado by means of artesian wells.



A. Guadalupe Mountainstone. 2. Coarse yellow and gray quartzose sandstone. 3. Rhynchonella bancalcareous conglomerate. 9. Upper Fusulina bed.



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no evidence that water cannot be obtained upon the Llano Estacado by means of artesian wells.

I am, sir, with much respect, your obedient servant,

GEO. G. SHUMARD,
Surgeon and Geologist P. R. Survey.

TO CAPTAIN JOHN POPE,
Corps Topograpical Engineers,
In charge of Pacific Railway Survey.

REPORT AND ANALYSES

OF

TEXAS SUMACH,

(*Rhus Copallina*).

BY

GEO. H. KALTEYER,
Analytical Chemist, San Antonio, Texas.

REPORT AND ANALYSES OF TEXAS SUMACH.

BY GEO. H. KALTEYER, CHEMIST.

SIR—I have the honor to offer the following report and analyses of the sumachs found in the State of Texas, as well as a comparison of such as are found in the other States of the Union and those produced in Europe.

At your request I commenced the analyses of "Texas Sumach," or *Rhus Copallina*, in the month of July, 1873, with the view of resolving the following doubtful points, viz:

First. What period of the year is most favorable for the collection of the article?

Second. How much of marketable sumach will one hundred pounds of the green article give?

Third. What percentage of tannin is found in the various parts of the plant, such as the leaves and young branches, the stems, the berries, the roots and the bark of the roots?

Fourth. What method should be adopted to prepare the article for market, having special reference to its economy and value?

Fifth. How does the Texas sumach compare with that produced in other places and now found in market—especially in its comparative richness in tannin?

Having clearly defined the points of interest to be ascertained, I propose before touching the subject to be answered to give a brief sketch of the plant, its history and uses.

The sumach is a small tree or shrub of the natural order *Anacadiacæ*, and is represented by the single genus *Rhus*, which implies the color of the berries.

The shrub is found in various parts of the United States and in Southern Europe. There are many species of the plant, but I shall confine myself only to those used in commerce.

In Europe we find of the species the *Rhus Coriaria* and *R. Cortinus*—these are known in the commercial community as the "Sicilian Sumach;" the *R. Myrtefolia* is another species growing in the vicinity of Avignon and Montpelier, in France; in Spain as well as Portugal we find the plant again growing, but of an inferior quality; in the United States we find the *R. Typhina*, or Stag-horn Sumach, the height of which is about twenty feet; then the *R. Glabra*, or Smooth Sumach, from four to ten feet high, whose leaves spread out; following this we find the *R. Pumila*, a species chiefly found about the barrens of Georgia and North Carolina, of a dwarfish height, varying from one to seven feet; in Vermont we find the *R. Aromatica*, which is also dwarfish and

of a straggling character, known as the "Fragrant Sumach," and found as well westward as southwestward of that State. In the southern part of Florida we encounter the *R. Metopium*, which attains a height somewhere about twenty feet; in Alabama we see yet another species, the *R. Cotinoides*, which, in the opinion of Gray, is the *R. Cotinus* (an exotic), or the "Venetian Sumach, or Smoke Plant."

Through the kindness and aid of Mr. Ferdinand Lindheimer, a gentleman well versed in botany and thoroughly informed on the subject as it pertains to this State, I have been able to collect that species in which we are most interested, viz: the *Rhus Copallina* or "Dwarf Sumach;" this latter name was obtained for it in the Northern States, where it is found of a diminutive size; here in Texas we find it reaching the height of sixteen feet, with branches and petioles, pubescent leaflets nine-twenty-one, oval, lanceolate or oblong, acute or acuminate, shining above, pubescent beneath, unequal at the base, petiole winged, panicles terminal, thyrsoid, sessile, sometimes leafy, drupes red, hairy (vide Gray and Torrey Flora North America).

Another species, the *R. Trilobata*, is found growing on the edge of thickets or in rocky districts.

Mr. Lindheimer has discovered in this State two other species, which he has named as the *R. Virens* and *R. Mycrophilla*, the first of these the Comanche Indians use as tobacco which they smoke, the other, a very high shrub and of very rare occurrence.

Thus it will be seen that this State produces also its varieties of the species, the most abundant, however, being the *R. Copallina*.

The uses to which this article is applied are in tanning and dyeing. The leaves (previously dried and ground) are used to tan fine Moroccos, and other light leathers, such as the skins of sheep, goats, etc., and the coloring matter produced also by a decoction of the leaves, is used in dyeing cotton, etc. These dyes are thus formed: the fabric having been immersed in the mordant (which is a solution used to fasten the color) of sulphate of zinc, yields (after it passes through the decoction of the sumach leaves) a brownish yellow color; a mordant of tin renders the fabric yellow; with acetate of iron (weak or strong) a gray or black. The bark of the *R. Glabra* or Smooth Sumach is used as a mordant for red colors.

TEXAS SUMACHS.

Commercially, those sumachs have the greatest value which are most abundantly supplied with tannin, hence to determine its qualities in this respect, I have carefully collected our species, the *R. Copallina*, bi-monthly, and ascertained the amount of tannin contained in the different parts, as well as the loss by drying, as seen in Tables Nos. 1 and 2.

The sumach was collected at a point, fifteen miles northwest of this city, on the Helotes creek, and was always gathered at the same place.

TABLE NO. 1.

Comparison of Leaves, Stems, Berries and their loss in drying.

Sumach when gathered.		100 parts of green Sumach gave.			100 parts of green leaves, stems and berres gave dried.			100 parts of green Sumach (leaves, stems and berries) gave dried.	Remarks.
No.	Date.	Leaves.	Stems.	Berries.	Leaves.	Stems.	Berries.	Leaves.	
1	July 12	66.66	33.34	. . .	38.70	50.00	. . .	25.80	
2	July 26	67.56	32.43	. . .	43.00	46.87	. . .	29.05	Began to flower.
3	Aug. 9	66.25	33.75	. . .	45.28	53.12	. . .	30.00	Flowers.
4	Aug. 23	62.50	37.50	. . .	55.00	55.88	. . .	34.37	Flowers fully developed.
5	Sept. 10	54.69	21.87	28.12	51.43	50.00	44.44	31.25	Berries appear.
6	Sept. 20	50.00	23.75	27.50	57.50	60.52	59.09	28.75	Berries
7	Oct. 11	50.00	21.43	32.15	46.42	62.05	85.00	22.11	Berries.
8	Nov. 1	50.98	17.65	32.29	59.61	61.11	90.62	30.39	Berries but young branches

TABLE NO. 2.

Showing the percentage of Tannin.

Commercial Dry.		Dried in Air Bath at 100 degrees Cent.					
No.	Leaves.	Leaves.	Stems.	Berries.	Roots.	Bark of Roots.	Remarks.
1.	16.88	21.87	2.50	. . .	. . .	. . . .	
2.	15.14	21.18	1.99	. . .	. . .	. . . .	Began to flower.
3.	17.29	17.41	3.20	. . .	. . .	. . . .	Flowers.
4.	21.82	22.76	3.84	. . .	. . .	. . . .	Flowers fully developed.
5.	19.02	19.26	2.90	7.71	. . .	. . . .	Berries appeared.
6.	18.76	18.86	3.79	6.67	. . .	. . . .	Berries.
7.	17.87	18.00	3.09	6.42	. . .	. . . .	Berries.
8.	21.08	21.73	4.24	5.93	7.34	13.50	Berries, but small.

I have also taken occasion to observe what influence rain and moisture had upon the chemical constituents of the plant; for that purpose I obtained the following table from "Dr. Peterson, Meteorological Observer," of this city, showing the days of rain and frost during the period of growth, which proves that the vegetation of this year was thrown back one month, and as a consequence, had the season not been unpropitious, we should have been able to collect it one month earlier.

TABLE NO. 3.

Showing Frost and Rainfall During First Ten Months of 1873—*Late Spring Frost. March* 26, *April* 9, *and* 16—*Days of Rain and Rainfall.*

Month.	Dates.	No. Days.	Rainfall. Inches.
January		3	0.68
February		7	0.43
March		9	2.43
April		2	0.58
May	4, 5, 9, 22, 26, 27, 30,	7	4.34
June	1, 2, 3, 4, 5, 6, 7, 10, 11, 14, 15, 16, 18, 19, 20, 21,	16	9.37
July	17, 18, 19, 24, 29,	5	2.56
August	10, 12, 17, 21, 24, 25, 27,	7	1.89
September	10, 11, 12, 13, 27,	5	5.94
October	16, 17, 18, 23, 25,	5	3.96
	Total	66	32.18

Having given the history and uses of the subject of this report, I propose, by aid of the tables above, to exhibit a tangible answer to the five propositions contained in the beginning of this report.

By an observation of Table No. 1, it will be seen that the weight of the leaves increased until the appearance of the berries, and on being dried and ground the largest percentage was obtained in the latter part of the month of August; therefore the proper period for collection is from the time of flowering, say in June, until the berries commence to appear in August. The latter part of the first month should be the favorable season to commence, and end in the latter part of August. The flowers may be gathered with the leaves.

The same table shows that one hundred pounds of green shrub produced 34.37 per cent of dried leaves fit for commerce; hence three tons of the green substance will produce one ton of commercial sumach.

The third proposition is answered by Table No. 1, and it will there be seen that the proportion of tannin contained in the various parts of the plant increases in the ratio to the sum of its weight, and vice versa, so that by the proper gathering season, we have twenty-two and seventy-six hundredths per cent of the desideratum (tannin). By reference to the table it will also be seen, that the most valuable part of the plant is its leaves, the rest being comparatively useless. By reference to Table No. 3, it will be seen that the heavy rains which fell in September and October had a tendency to increase the amount of tannin in the last collection, made November 1; hence the proof, that a rainy season is beneficial to the production of tannin. The same holds good for its production in August, as by reference to the same table it will be observed that there was a heavy rainfall in the months of May and June, and consequently an increase of tannin.

I propose to prepare the article for market by first cutting the youngest branches (latest growth) including flowers, permitting them to lie on

the ground for one or two hours, and then removing them to the place of drying, which process should be conducted by the aid of heat moderately applied until dry, (the heat not to exceed 80 degrees C. or 176 degrees Fahrenheit.) I prefer this process (kiln drying) to the others in use as having given the good results now offered in this report. In Sicily the leaves are thinly strewn on a meadow, and there dried in the sun; but great care must be taken to keep them out of dew and rain, as moisture aids fermentation and consequently destruction of tannin. In Virginia drying is employed by means of the shade. Having dried the leaves by one or the other of these processes, they should be well threshed, and all the detached leaves with their flowers and small stems, should be gathered and carried to the mill, where, after being ground, they should be sifted and packed in bags forty by sixty inches. (Fifteen bags to the long ton of twenty-two hundred and forty pounds, the article always being sold by that weight.)

I propose that the mill to be used should be such as may be found engraved in the Agricultural Report of the year 1869 of the United States Commissioner of Agriculture, and which can be found on page 232. The mill consists of a heavy solid circular bed of wood, marked "A" in engraving, fifteen feet in diameter, with a depression around the edge, "B," a few inches deep and a foot wide, for the reception of the ground sumach from the bed, and two chasers or rollers, "C C," weighing about two thousand five hundred pounds each, five or six feet in diameter, and provided with teeth of iron, or preferably of wood, thickly inserted. If the axle of a cart were set upon a pivot in its center, the wheels of the cart would describe a compound revolution similar to that of the chasers of a sumach mill. Most mills have to be stopped to allow the unloading of the bed, but a process exhibited in the engraving has been patented by Mr. Chase, of Alexandria, Virginia, which obviates this delay. The apparatus consists of an angular arm, "D," attached to a scraper, "E E," and worked by a lever, "F," which passes through the hollow shaft, "G," and extends to the room above, where it terminates in a handle, as seen in the section at the top of the engraving. The scrapers carry the ground sumach to the opening, "H," whence it is carried by an elevator to the sieves, such as is common in flour mills, and the grinding is done by the application of the upright shaft, "G," between the chasers, which moves them.

The price of such a mill as described in the Agricultural Report is about three thousand dollars. But a mill on the same plan can be constructed by almost any mechanic for a less sum—that is to say, it will answer the same purpose, without being so elaborately factored. In Europe the mode of grinding is by stones on a smooth stone bed.

DEPARTMENT OF AGRICULTURE, INSURANCE, STATISTICS, AND HISTORY.

GEOLOGICAL SURVEY OF TEXAS.

E. T. DUMBLE, State Geologist.

BULLETIN No. 2.

A PRELIMINARY REPORT

ON THE

SOILS AND WATERS

OF THE

UPPER RIO GRANDE AND PECOS VALLEYS

IN

TEXAS.

By H. H. HARRINGTON,

[illegible]

DEPARTMENT OF AGRICULTURE, INSURANCE, STATISTICS, AND HISTORY.

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BY H. H. HARRINGTON,

Professor of Chemistry and Mineralogy, Agricultural and Mechanical College of Texas.

AUSTIN:

STATE PRINTING OFFICE.

1890.

INTRODUCTION.

The question of irrigation along the upper Rio Grande being one of great importance to the citizens of El Paso County and to the State generally, it was decided that an examination of the soil and water of that section should be made in order that there might be proper data from which to discuss the feasibility of irrigation should a suitable dam be built above El Paso. Prof. H. H. Harrington, of the Agricultural and Mechanical College, was selected to make the investigation, and in the report herewith submitted he gives the results of his work.

To this is added a like discussion of the soils of the Pecos Valley and water of the Pecos River. These specimens were collected under the instructions of this department by Mr. B. K. Brant, and represent the characteristic soils of that region.

The results show clearly the absolute necessity for just such investigations as are here recorded. The examination of the soils of the Rio Grande and Pecos valleys proves that they are equally fertile and that both need only the requisite supply of suitable water to render them highly productive.

Irrigation has been carried on for years on the Rio Grande, and the results obtained in practice fully corroborate those brought out by the chemical analyses of the water of that river as regards its entire suitability for irrigation, if it can be obtained in proper quantity.

Preparations are now being made to use the water of the Pecos River for irrigating the lands lying in the valley. The analysis of this water shows that it contains so large a quantity of salt as to make it advisable to proceed with the utmost caution in this work. It is true that salt, being readily soluble in water at all temperatures, would be carried off to a greater or less extent by the rains falling upon the soil during the year, but it would seem rather a dangerous experiment to put the amount of salt as shown upon soils already amply supplied with alkaline material, even with all the possibilities of its being leached out again by later rains. The danger is more fully shown if we take into consideration the existence of such spots as are described under soil specimen No. 4, which offer strong proof that the rainfall is entirely insufficient to accomplish a work of this kind.

The results of the analyses of the Pecos water are fully verified by the report of Mr. C. C. McCulloch, Jr., of this Survey, who made a personal examination of the river and new canal. He says: "The banks of the river are lined with incrustations of salt left by the evaporation of the river water, and present a very white appearance to the eye. The sides of the canal are

similarly incrusted, and the salt appears in places in spots on the ground. I did not observe any salt spots in the freshly irrigated fields. The water does not taste salty and is used for drinking purposes." (It requires over 150 grains of salt per gallon to give any salty taste at all.)

The difference in the character of the water of the two rivers is readily explainable, being due entirely to the difference in composition of the geologic formations through which they pass. The Rio Grande flows down through the harder materials of the Rocky Mountains, and carries little besides red clay in suspension, while the Pecos cuts through the softer strata of the Permo-Jura-Trias, containing beds of salt and gypsum. It must be fully understood, however, that the conclusions reached concerning the use of Pecos River water apply only to that stream and not to the various other sources of water supply in the Pecos country.

One very valuable fact brought out by this investigation is the relation existing between the amount of lime contained in certain soils in Western Texas and the difference of vegetal growth thereon—those low in lime bearing only cacti and those containing a higher percentage carrying a fine growth of mesquite. The importance of this determination is immediately apparent to any one who has ever seen the treeless expanses of Western Texas.

The results shown and conclusions reached by Prof. Harrington are presented with the hope that they will prove of especial value to those in any way interested in Western Texas, and as showing most plainly the intimate relations which exist between chemical geology and many questions of practical agriculture.

E. T. DUMBLE.

SOILS AND WATERS

OF THE

UPPER RIO GRANDE VALLEY IN TEXAS.

BY

H. H. HARRINGTON.

Professor of Chemistry and Mineralogy, Agricultural and Mechanical College of Texas

Mr. E. T. Dumble, State Geologist:

SIR—Having been detailed by your Survey for special work upon the soils of the upper Rio Grande valley in this State, and for an inquiry into the economic aspects of that country as related to agriculture and its allied arts, I have the honor to present herewith my report on the work done.

The analytical part of the work was executed by Mr. P. S. Tilson, chemist of the Geological Survey, at the laboratory of the Agricultural and Mechanical College.

I beg to acknowledge the many kindnesses shown me in camp by Mr. W. H. Streeruwitz, geologist for Western Texas, special favors by Messrs. Rubenstein and Buchanan of Ysleta, Mr. S. J. Etheridge of San Elizario, and the courtesies of the railroad employes at Sierra Blanca.

Yours, very truly,

H. H. HARRINGTON, Chemist.

AGRICULTURAL AND MECHANICAL COLLEGE OF TEXAS,
December 1st, 1889.

SOILS AND WATERS

OF THE

UPPER RIO GRANDE VALLEY IN TEXAS.

The investigation into the character of the soils of the upper Rio Grande Valley as planned, consisted of a personal examination of that part of El Paso County adjacent to the Rio Grande from El Paso to a line below the site of Fort Quitman, for the purpose of ascertaining the character of soils and of the water supply, with especial regard to their capacity and suitability for irrigation.

The scope of country investigated is some eighty miles in length and from two to six miles in width, varying with the breadth of the valley, upon the Texas side of the Rio Grande, and having an average width of about three miles. For this entire length the valley is either traversed or skirted by the G. H. & S. A. R. R. and the T. & P. R. R., these railways using the same track from El Paso to Sierra Blanca, ninety miles southeast. For about thirty miles below El Paso the greater part of the valley is now under cultivation. In many instances the orchards and vineyards are brought up to the highest state of perfection, rivaling in beauty and value those of the Pacific Slope. Many varieties of grapes are grown in the most satisfactory manner. Pears, peaches, apples, and plums are also found in many different orchards. Vegetables of almost every variety and melons of different kinds give the most satisfactory returns to the market gardener. Of the farm crops proper, corn, oats, wheat, rye, and alfalfa seem to be the most important. Alfalfa is grown in great quantity and, as represented by responsible and prominent farmers in the valley, very profitably; from two to four cuttings are made during each season, and from two to three tons to the acre are produced at each cutting, the value of which is from ten to fifteen dollars per ton. These variations in the quantity raised are dependent almost entirely on the supply of water for irrigation. The supply of irrigating water as managed at present is entirely inadequate to meet the demands of the valley, or even to properly supply that portion of it now under cultivation. In many instances a crop is entirely lost from a want of a supply of water at the proper time, and often water is obtained too late to give anything like satisfactory results. In consequence of this and of the class of farm laborers employed, farming proper is very improperly managed and conducted. Most of the Americans living in the valley give their attention to viticulture, orchards, or market

gardening. The farms are generally rented by Mexicans, whose system of agriculture is very crude. They use no improved implements and do their cultivating entirely by hand, which of course operates very much against the rapid development of the country in this direction. As a proof of this statement, and of the scarcity of the supply of water at present, I need only say that land valued at from twenty to forty dollars an acre can be rented at from twenty-five cents to one dollar an acre. It is true that this is in part explained by the land being held at speculative prices; but the same conditions must prevail to a large extent until the system of labor is changed and agriculture be conducted more in accordance with the recognized principles of that industry.

SOILS.

The soils of the valley may in a general way be divided into three classes:

First—The heavy "adobe" soil of the river deposit.

Second—The sandy loam, being an intimate mixture of the adobe soil with the sand of the foothills adjacent to the valley.

Third—The sandy soil, containing an excess of the sand from the foothills.

The adobe soil is the most difficult to cultivate, is plastic, and is generally supposed to contain a larger amount of alkalies than either of the other soils. The sandy soil is regarded as the best adapted for vegetables and alfalfa, while the sandy loam, which is the predominating soil, is used for various crops.

ADOBE SOIL.—This soil was taken from the valley between El Paso and Juarez (Paso del Norte), Mexico. So far as could be judged it was selected as a typical "adobe" soil.

CHEMICAL ANALYSIS.

	Per Cent.
Volatile and organic matter	9.17
Soluble silica	0.21
Insoluble silica	76.01
Ferric oxide	3.20
Alumina	4.04
Phosphoric acid (anhydrous)	0.12
Sulphuric acid (anhydrous)	0.31
Lime CaO.	3.53
Carbonic acid gas	2.05
Alkalies as chlorides	3.24
	101.88

MECHANICAL ANALYSIS.

	Per Cent.
Siftings	15.39
Sand, .25 to .05 mm.	39.71
Silt, .05 to .01 mm.	4.97
Dust, .01 to 0 mm.	24.01
Clay (by difference)	4.79
Loss on ignition	11.13
	100.00

The soil gives a faint alkaline reaction in cold solution; distinctly alkaline on boiling. The chemical analysis makes a good showing for the soil. The "chlorides" consist principally of common salt. The quantities of organic matter, lime, iron, sulphuric and phosphoric acids, are such as are found only in productive soils.

Sandy Loam.—The following is the analysis of two samples of the sandy loam soil from near San Elizario Station, about thirty miles below El Paso. There is little difference in the analyses of the two samples, and comparatively little between these and that of the "adobe" soil, except that the quantity of sand is considerably increased while the organic matter is very much less. There is, according to the popular opinion, a slight excess of alkalies in the "adobe" soil. From the examination made I think that this slight excess will prevail throughout the entire valley. The alkalies in these samples also consist principally of common salt. There appears to be little of the highly corrosive carbonate of soda in any of these soils which is so prevalent in the waters and soils of California and States and Territories of the Northwest.

CHEMICAL ANALYSES.

	1	2
Organic and volatile matter	4.48	4.45
Soluble silica	0.12	0.13
Insoluble silica	82.43	82.37
Ferric oxide	3.04	2.24
Alumina	1.67	1.95
Phosphoric acid (anhydrous)	0.29	0.36
Lime	3.68	3.79
Magnesia	0.15	Trace
Sulphuric acid (anhydrous)	0.94	0.28
Carbonic acid gas	2.06	2.46
Alkalies as chlorides	2.54	3.03
	101.40	101.06

MECHANICAL ANALYSIS.

	Per Cent.
Siftings	1.91
Sand, .25 to .05 mm	78.02
Silt, .05 to .01 mm	7.48
Dust and clay, (.01 to 0 mm. by difference)	5.82
Loss on ignition	6.77
	100.00

The analyses of these two examples of this soil fully explain and sustain the great fertility shown in the practical cultivation of the crops. The small percentage of sulphuric acid and the comparatively large amount of carbonic acid shows that the lime is present as limestone or carbonate, and not as gypsum or sulphate.

The quantity of alkalies, soda and potash, as reported in all these soils, is much larger than is generally found in soils. It is a well known fact that an excess of common salt is injurious to plant growth. But exactly what constitutes this excees has not, so far as I know, been determined; but it is certain that the maximum limit has not been reached in the case of these soils, as is evidenced by their exceeding fertility. In certain cases small quantities of salt are beneficial to land, and it frequently gives good results when applied as a fertilizer; but the quantity in which it is applied is never sufficient to constitute anything but a small fraction of one per cent of the soil. In these cases its office seems to be not to act as plant food itself, but to decompose the double silicates of lime and potash and set them free and render them available as plant food. When there is a slight excess of salt it checks the rank growth of plants, and if the excess is considerable the plants will be destroyed entirely, particularly if the salt comes in contact with the roots of young plants. It has also been determined in case of certain alkali soils that were entirely barren that by decreasing the quantity of alkali the soil was restored to fertility: but so far as I can ascertain the maximum quantity of alkali that any one crop would tolerate and still thri e and do well has not been determined. The character of the soil would undoubtedly have great influence in this matter. The consideration of this question is of great importance in certain districts where the soil already contains considerable quantities of alkali and is to be irrigated with a water also carrying alkali in solution, which amount is to be added year by year to the amount already accumulated in the soil.

CHEMICAL ANALYSES OF SOILS FROM FOOTHILLS AROUND SIERRA BLANCA AND BORDERING THE RIO GRANDE VALLEY.

	No 1.	No. 2.	No. 3.	No. 4.	No. 5.
Organic and volatile matter	8.33	4.19	7.65	3.10	4.26
Soluble silica	0.44	0.73	0.29	0.17	0.13
Insoluble silica	78.63	88.26	74 85	66.55	81.88
Ferric oxide	7.44	1.44	4.08	2.88	3.36
Alumina	2.22	1.12	3.84	1.45	2.70
Phosphoric acid (anhydrous)	0.34	0.25	0.60	0.21	0.19
Lime, CaO	0.57	1.28	3.83	13.65	3 84
Magnesia, MgO	...	Trace	Trace	0 96	0.81
Sulphuric acid (anhydrous)	0.38	0.58	0 73	Trace	0.78
Carbon dioxide	Trace	0.60	2.13	9.52	2.10
Potash, K_2O	0.52	0 33	0.43	0.47	0.26
Soda, Na_2O	0.46	0.78	0.85	0.29	0.67
	99.33	99.57	99.28	99.25	101.26

No. 1 comes from ten miles north of Sierra Blanca, and is a red sandy soil.

No. 2 is from the valley three miles northeast of Sierra Blanca.

No. 3 is from ten miles west of north of Sierra Blanca, the grass being excellent.

No. 4 is from eight miles south of Sierra Blanca. The grass is good, and an excellent growth of mesquite brush.

No. 5 is from Sierra Blanca.

The noticeable features of these soils are the large quantity of iron they contain, and the comparatively large amounts of potash and phosphoric acid, excepting nitrogen, the two most valuable ingredients a soil could contain. The percentages of lime, carbonic and sulphuric acids are rather small for Texas soils, but still sufficiently large for agricultural needs. One important fact, however, should not go unnoticed. In No. 4 the quantities of lime and carbonic acid are both large, showing that the lime is present as the carbonate; and on this soil there is not only a good growth of grass, but the mesquite underbrush is thick and weighted with fruit. This is an exception to the general growth of the foothills. Usually there is plenty of nutritious grass, but little else except cacti. In the spot where No. 4 was collected the cactus is entirely replaced by the mesquite. In a general way, we may say there is little doubt but that lime applied to these soils, either as the sulphate, gypsum, or as the carbonate, would be beneficial. The absence of "alkalies" is a very fortunate characteristic of the soils.

ALKALI SPOTS.

The Rio Grande valley, as I observed it, is dotted with spots of alkali. They seem to occur irregularly, anywhere in the valley. Sometimes they have been brought into cultivation, but more frequently they are left alone as

not being worth the trouble and expense of reclaiming. They vary in area from one-fourth of an acre to eight or ten acres. I have submitted the incrustation of some of the uncultivated spots to a partial analysis:

SOIL INCRUSTATION.

BLACK ALKALI.—From Ysleta, Texas—

	Per Cent.
Lime	4.48
Sulphuric acid (anhydrous)	6.39
Carbonic acid gas	2.23
Soda (oxide of sodium)	11.23
Potash (oxide of potash)	.09
Chlorine	6.53

The soda is present as chloride, sulphate, and carbonate; the lime as silicate and carbonate. This analysis represents a sample of what is known as "black alkali," to distinguish it from a white incrustation, which is known as "white alkali." As far as observed by me the chief difference between the two is the more complete sep^ration of sodium chloride in the "white alkali." Another specimen from the valley ten miles below Fort Hancock gave on partial analysis:

	Per Cent.
Lime	7.73
Sulphuric acid (anhydrous)	.51
Carbonic acid gas	2.80
Soda (oxide of sodium)	1.16
Potash (oxide of potassium)	0.41
Chlorine	1.16

A remarkable feature in this incrustation is the presence of chloride of lime. Sodium carbonate is also present. The two together make an exceedingly viscous combination. The sample of incrustation is very hygroscopic When taken it was moist, although taken from a climate that is so dry as to partially dehydrate citric acid. It would be classified as black alkali, and comes from an adobe soil.

WHITE ALKALI.—An incrustation from the Rio Grande valley above El Paso, in New Mexico, showed in 100 parts of the material, which were soluble in water and which amounted to forty per cent of the entire mass:

50.99 parts alkalies as chlorides.

3.87 parts of lime.

19.77 parts of sulphuric acid.

Phosphoric acid and magnesia absent.

This is a sample of white alkali.

RECLAIMING ALKALI SPOTS.

To accomplish this result various methods are resorted to. Beets grown upon the soil seem to dissipate the alkali. Barnyard manure, when it can be obtained, improves the condition very much. Sometimes simple cultivation without an attempt to grow any crop is practiced with very favorable results. If irrigation can be applied the chlorides are soon carried away, or below the surface, and where only chlorides are present the spot is rapidly brought to a state of cultivation. Unfortunately this cannot be generally done since the supply of water is not even sufficient for the crops. Frequently sorghum is grown, which is a profitable money crop, and valuable for reclaiming the soil. Gypsum has not, so far as I could learn, been used. But in many instances its use would probably be attended with the most satisfactory results, while in other cases it would probably be of little benefit.* In all cases the alkali should be subjected to chemical analysis, and then intelligent methods could be directed for reclaiming the soil.

SEDIMENTS.

In the ditches used for irrigating there accumulate considerable quantities of mud and other matter, which is carried by the river water in suspension and in solution. This deposit, when it becomes dry in the bottom of the ditches, cracks, curls and breaks into pieces of various sizes. From time to time it is removed and thrown upon either side of the ditch, the banks of which are gradually built up. Below are given the analyses of two samples of this deposit. There is considerable difference in the composition of these sediments, owing to the difficulty of collecting the deposits in a state of purity, and even more due to the nature of the soil underlying the ditch. The frequent alternations of flooding and evaporation of water from the bottom of the ditch will ultimately accumulate at the surface all the alkali which exists in the soil to a considerable depth. Hence in collecting a sample of the sediment, should it happen to be from a place where the ditch passes over an alkali spot, the quantity of alkali shown by analysis is likely to be much greater than would appear in the analysis of a sediment gathered from any other place.

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*Large quantities of gypsum have just been found west of the Quitman Mountains, which is directly in the line of the railroad, and within a few miles of this valley, being, in fact, in the line of hills which forms its southern boundary. E. T. D.

RIVER SEDIMENTS.

From San Elizario Station. Partial analysis.

	1	2
Organic matter	2.77	0.00
Lime	5.60	3.78
Sulphuric acid (anhydrous)	0.59	2.94
Soda (oxide of sodium)	11.23	16.56
Potash (oxide of potassium)	.09	1.65
Carbonic acid gas	3.44	1.65

We have only to look at the percentage quantities of soda in these to be convinced as to the accumulation of alkali; but they come from old ditches where accumulation has been going on for some time, and do not fairly represent a river deposit. This could be obtained with accuracy only by allowing the water to settle in a clean vessel, and collecting the sediment from that.

WATER SUPPLY.

This is the one question upon which the development of the valley depends. Without water of the proper kind in the valley, and in sufficient quantity for irrigation, very little progress can be made. With a proper water supply the capabilities of the valley can hardly be overestimated. In various places water can be found within eight feet of the surface—in a bed of quicksand—it is said; but the quantity is sufficient only for family purposes, and in many cases is not well adapted even for this use. The quantity of alkali is excessive, often so much as to kill young plants where used for irrigation. It is generally understood that the best water obtained at or about this depth is from the old river bed, which traverses almost every part of the valley, in which the water is better, because the alkali is less. It is supposed that in the old river the water dissolved and carried away the alkali from the soil adjacent to its bed. So far as I could ascertain no decided effort has been made to obtain artesian water in the valley. At Fort Hancock, fifty miles below El Paso, the post bored 225 feet, but obtained no water. I think that this is the greatest depth that has been reached in the valley, and it is not sufficient to make a satisfactory test of the matter. However, some geologists have expressed the opinion that flowing water can not be obtained here.

On the foothills, at various points along the Galveston, Harrisburg & San Antonio Railroad, more or less removed from the valley, water has been obtained at depths varying from 700 to 2000 feet. Not flowing water, but within easy pumping distance. At Fabens, 35 miles from El Paso, water was obtained at a depth of 27 feet. The well furnishes, by pumping, all the water necessary for the railroad storage tanks located at this place. I have no

analysis of this water, but think it is comparatively free from alkali. If so, and other wells could be obtained like it, it would perhaps be the simplest solution of the irrigation problem. On the mesa, eight miles northeast of El Paso, the Lanoria Mesa Company are sinking a system of wells, with the object of irrigating and improving the mesa. The mesa is a level plain having an elevation of one hundred and eighty feet above the level of the valley at El Paso. On the west it abuts against the precipitous cliffs of granite, limestone, and porphyry, which are much tilted. Some miles to the east the plain breaks into hills; small, but steep cliffs, and shallow, but sometimes precipitous canyons. It is the same general contour of country found bordering the east side of the valley for two hundred miles or more.

The following are the strata as described by the engineer who bored one of the wells on the mesa.

Surface clay	18 feet
Sand and gravel	45 "
Clay	10 "

Sand and clay alternate from this until a depth of 230 feet is reached, where there occurs a bed of sand and gravel mixed, which is seventy-four feet in thickness. This is the depth at which water is first obtained. After passing through the bed of sand and gravel, and through a bed of clay ten feet thick, a large quantity of water is obtained in a bed of sand twenty-four feet thick, resting presumably upon a bed of clay. The well is 340 feet deep, the depth of water being 120 feet.

The water is pumped by windmills. While the capacity of the well is not known, it has furnished, so the company informed me, 16,000 gallons in twenty-four hours without lowering the column of water in the well.

ANALYSIS OF MESA WELL WATER.

	Gr. to Gal.
Suspended matter (inorganic)	2.80
Total solid residue in clear solution	36.65
Organic and volatile matter	6.15
Total mineral matter	30.20
Again soluble	29.80
Lime	3.63
Alkaline chlorides	3.19
Sulphuric acid (anhydrous)	5.52

The water has an alkaline reaction in the cold, which is increased by boiling; is clear and colorless, and the suspended matter settles easily. The sample was sent in a sealed demijohn, and when opened emitted considerable odor of sulphuretted hydrogen, but the quantity was not sufficient to estimate. While the total amounts of soluble mineral matter and alkaline chlorides are

somewhat large, they are not sufficient to interfere with the use of the water for irrigating purposes. The water may be said to be free from any alkaline taste, and is an excellent drinking water.

ANALYSIS OF RIO GRANDE WATER.

	Gr. per Gal.
Suspended matter (inorganic)	98.65
Total residue in clear water	40.65
Organic and volatile matter	5.05
Total soluble matter	29.15
Lime	4.65
Sulphuric acid (anhydrous)	3.23
Alkaline chlorides	1.77

Silica, iron, and alumina not determined.

The water when collected was very muddy, hence the large amount of suspended inorganic matter, which is more than twice the quantity of matter held in solution. It has a slight alkaline reaction. The river water has for a long time been used for irrigating; indeed, it is the one source of supply for that purpose at present. The fact that it will rapidly remove alkali from alkali spots in the valley is most conclusive evidence of its value for irrigating purposes. The water contains a comparatively large quantity of gypsum and of potash, two substances that add greatly to the fertility of most soils. The quantity of mineral matter, as carried by the river water and in a finely divided state deposited from time to time over the surface of the soil, tends to improve its mechanical condition and to add to its fertility.

QUANTITY OF RIVER WATER.—The great obstacle in the way of irrigation in the valley at present is the insufficient quantity of river water, which is not sufficient to supply even the present demands made upon it, much less to permit any increase in the acreage of cultivation, as there is a constantly growing desire to do. During the early part of the year the river usually furnishes all the water now needed, but as the season advances the supply grows less, and many crops that come up and start well to growing are entirely lost from insufficient water supply. At some time in the early summer, when the ice melts on the upper tributaries of the river, there is a rise for a short time, not being of sufficient duration, however, to be of much value for irrigating.

Until good water is supplied in sufficient quantity there can be no increasing and permanent prosperity in this valley. There is one way to increase the water supply from this source, and this is by the construction of storage tanks, and by holding back the high water of the river for distribution to the growing crops later in the season. If this is done in a systematic and scien-

tific way, it will make the upper portion of the Rio Grande Valley one of the most desirable districts in the State.

WATER RESERVOIRS OR STORAGE TANKS.—In many places along the foothills, contiguous to the valley, water reservoirs could be easily and economically constructed at the mouth of gorges and across channels of mountain streams. The water so obtained might not generally be sufficient for irrigating on an extensive plan, because the rainfall is hardly sufficient for the accumulation of such large bodies of water, in addition to which the exceedingly dry climate, with a constant wind, that might be often called a gale, would rapidly evaporate water from such accumulations. The fact is frequently advanced as an argument against the expediency of building water reservoirs in this climate; but I believe such tanks could be constructed with profit, where the aim is to combine cattle raising with farming. There is at present in El Paso county a tank formed by the old bed of the Texas & Pacific Railroad crossing the channel of a mountain valley; here, some 1500 head of cattle are supplied with water for many months. The foothills are covered with a good supply of gamma grass, which is very nutritious, and of which stock are very fond. It serves alike for summer and winter pasturage. In the valley there is comparatively no grass; although there are some 6000 head of cattle in the valley from El Paso down to Fort Quitman. Many of these cattle range on the foothills, and travel eight or ten miles daily to the river for water. During the winter they do not go nearly so frequently, as the Prickly Pear cactus furnishes them nearly all the water they require. If water could be supplied in the foot hills many cattle could be pastured there, while small plots of ground could be irrigated, furnishing an orchard, garden, lawn, etc. As the number of tanks increased, the humidity of the atmosphere would increase, lessening evaporation, and if not increasing the rain fall, would at least make possible the accumulation and retention of large bodies of water. Again, I believe water within very easy pumping distance might be obtained at many places among the foothills.

NATURE OF ALKALI IN THE VALLEY.—So far as I have investigated this subject, I have found that common salt is the chief disturbing substance, though in one case chloride of calcium was found; and in other cases very small quantities of the alkaline carbonates may be present. As a rule, these are absent, except in mere traces. Still small amounts of gypsum should be used to neutralize whatever carbonate may be present. The sodium carbonate is exceedingly pernicious to the development of young plants. The chlorides can be removed, as mentioned above, by irrigation, blank cultivation, and application of barnyard manure. I believe that the value of the latter as a fertilizer is itself increased by the presence of common salt, if the quantity is small. Then such crops as beets, sorghum, alfalfa, should be grown until the land is brought into good tilth.

CONCLUSIONS.

1. The soil of the valley is exceedingly fertile, not heavily charged with alkali except in spots, and these can be reclaimed without great difficulty.

2. The water obtained eight feet below the surface in a bed of quicksand is too strongly alkaline for irrigation purposes, and is not even a good drinking water, although it is now so used.

3. The river water is well suited for irrigation; the quantity of mineral matter is large, as is that of the alkali chlorides compared to quantities in other river waters. The matter in suspension probably adds to the fertility of the soil.

4. The quantity of river water, under present conditions, is not sufficient to meet present demands. It should be collected in storage reservoirs during high water, and held for growing crops later in the season.

5. The present system of irrigation is unsatisfactory, inefficiently constructed, and badly managed. Farmers in the valley would gladly pay higher rates for more water and a better distribution of it.

6. The artesian water from the mesa hills is not so adaptable for irrigating purposes as is the river water; but it is sufficiently pure for use.

7. In many instances water could be collected in the foot hills by reservoirs, and cattle raising and farming combined with profit.

8. The system of labor in the valley is exceedingly defective and unsatisfactory; but this is a matter that will regulate itself with the improved conditions of the water supply.

9. The alkali can be removed by irrigation, deep and thorough cultivation, application of gypsum, manuring with barnyard manure, or by growing special crops that are conducive to the removal of saline matter. In all cases the work should be preceded by a chemical analysis of the soil.

SOILS AND WATERS OF THE PECOS VALLEY.

PECOS VALLEY SOILS.

I present, in addition to the above report, analytical work done by Mr. P. S. Tilson upon the Pecos Valley soils, and analyses of Pecos River water. The soils and water were collected under your direction and sent by you to this laboratory for examination. The following explanation and description was received with the samples:

No. 1. Upland loam, west side of Pecos River; very deep without apparent change.

No. 2. From the surface soil of Pecos City, one inch to two feet in depth; rests on No. 3.

No. 3. From twelve to fifteen feet deep.

No. 4. Exists in patches from ten feet in diameter to ten acres or more. Alkali soil.

No. 5. From river bank, west side, three hundred feet back from river, very deep.

No. 6. Upland soil from east side of river; averages eight inches in thickness; rests on No. 7.

No. 7. Eight inches thick; rests on No. 8.

No. 8. Dug about twenty inches into this; saw no change in the character.

No. 9. From east valley four hundred feet back from river; about ten inches in thickness; rests on No. 10.

No. 10. About six inches in thickness; rests on No. 11.

No. 11. Depth unknown.

ANALYSES OF PECOS VALLEY SOILS.

	Organic and Volatile Matter.	Soluble Silica.	Insoluble Silica.	Ferric Oxide.	Alumina.	Phosphoric Acid.	Lime.	Magnesia.	Sulphuric Acid.	Carbonic Acid.	Alkalies as Chlorides.
No. 1	11.97	0.26	58.7	3.20	7.78	0.13	5.6	0.30	4.1	5.1	2.3
No. 2	5.25	1.10	72.3	2.16	2.50	.08	5.6	3.2	2.0	3.5	2.6
No. 3	15.5	34.8	19.0	0.86	1.60	.09	12.6	0.6	11.4	2.3	2.0
No. 4	13.	.07	49.	2.97	4.12	Trace	12.6	2.2	2.5	7.3	6.1
No. 5	9.12	0.17	68.6	5.65	1.42	0.12	7.0	0.8	1.0	5.5	1.5
No. 6	6.7	0.14	77.0	4.47	0.73	0.21	5.2	Trace	0.9	3 2	2.3
No. 7	2.8	.03	85.5	2.42	1.89	0.14	3.3	0.62	1.1	1.4	2.7
No. 8	2.5	.04	87.7	1.27	0.44	0.09	2.1	0.2	1.26	3.1	1.5
No. 9	8.44	0.10	69.2	3.86	5.54	0.21	4.7	Trace	1.7	4.8	3.1
No. 10	8.02	4.2	60.1	3.14	5.11	0.2	8.5	Trace	5.0	5.6	1.2
No. 11	15.3	9.1	34.3	2.56	2.00	0.6	13.3	0.9	16.9	3.9	1.3

MECHANICAL ANALYSES OF PECOS VALLEY SOILS.

No. 1.

Upland loam, west side of Pecos River:

	Per Cent.
Siftings	0.69
0.25 to .01 mm	34.58
.05 to 0.1 mm	35.05
.01 to 0 mm	11.44
Clay (by difference)	2.02
Loss on ignition	16.22

No. 2.

From the surface soil of Pecos City:

Siftings	1.72
0.25 to 0.05 mm	76.18
.05 to .01 mm	7.62
.01 to 0 } Clay } by difference	4.31
Loss on ignition	10.17

9.69 per cent of sand was removed by the 0.1 mm seive. This was added to the 0.25–0.05 mm.

No. 3.

Siftings	1.06
0.25 to 0.05 mm	19.18
0.5 to 0.01 mm	5.22
.01 to 0 mm	54.04
Loss on ignition	20.50

No. 4.

Siftings	1.45
.25 to .05 mm	37.53
.05 to .01 mm } .01 to 0 mm } †	34.29
Clay (by difference)‡	3.65
Loss on ignition	23.08

†These two quantities seem to be about equally divided between .05–.01 mm. and .01–.0 mm.
‡Clay determined by 30 hours subsidence.

No. 5.

Siftings	0.39
.25 to .05 mm	50.29
.05 to .01 mm	19.56
.01 to .0 } Clay } by difference	7.67
Loss on ignition	13.09

No. 6.

Siftings	0.78
.25 to .05 mm—Sand*	75.43
.05 to .01 mm	11.12
.01 to .0 mm (by difference)	5.46
Loss on ignition	7.21

*13.96 per cent of sand was removed by the 0.1 mm sieve. This was added to the sand and the whole amount is included in above percentage.

No. 7.

Siftings	0.51
.25 to .05 mm—sand †	85.50
.05 to .01 mm	6.70
.01 to 0 mm (by difference)	2.34
Loss on ignition	4.95

†26.16 per cent of sand was removed by the 0.1 mm seive, which, added to the sand proper, gives the amount here quoted.

No. 8.

Siftings	0.41
.25 to .05 mm	92.73
.05 to .01 mm	2.82
.01 to 0 mm (by difference)	1.35
Loss on ignition	2.69

No. 9.

Siftings	1.76
.25 to .05 mm	34.91
.05 to .01 mm	19.12
.01 to 0 mm	11.64
Clay‡	19.33
Loss on ignition	13.13

	No. 10.	No. 11.
Siftings	10.4	2.93
.25 to .05 mm	61.71	29.59
.05 to .01 mm	8.71	17.39
.01 to 0 mm	7.33	10.10
Clay‡	5.67	19.70
Loss on ignition	15.54	20.28

‡ Clay was determined by difference, and contains that part of the grade having diameters from .01 to 0 mm, which remains suspended after 24 hours subsidence.

The mechanical analyses of the soils herein reported were made according to Dr. Osborne's method—that of Beaker Elutriation. Particles having

diameters between .25 and .05 mm. are designated as *Sand;* those between .05 and .01 mm. as *Silt;* those below .01 mm. as *Dust* or as Dust and Clay. There is no thoroughly reliable method of mechanical soil analysis. But this method and that of Hilgard's Churn Elutriator method give most satisfactory results. the work by either method approaching accuracy sufficiently to give a very correct idea as to the general mechanical condition of the soil. It will be noticed that these soils are mostly sandy: but in a few instances, the quantity of fine material is very great. In No. 3 the *Dust* is particularly large in quantity.

From the description No. 1. upland loam. seems to occupy considerable extent of country. Its analysis indicates an excellent soil. The subsoil is probably of the same general character as the top soil. No. 2 is a chocolate loam, having No. 3 as a calcareous subsoil. This lime is present as the carbonate and as the silicate. No. 4 is an alkaline loam. with a large quantity of organic matter present. The quantity of chlorides present is too large to permit its use. No. 5 is a red alluvial soil. Nos. 6. 7. and 8 are superimposed. The surface soil, No. 6. a black sandy soil; No. 7 has less organic matter and more sand; while No. 8 is almost pure sand. It is also noticeable that there is a gradual decrease of phosphoric acid and lime from the surface down. The quantity of alkalies in No. 8, sixteen inches below the surface, seems to have decreased very much. This is in keeping with the general tendency of alkalies to accumulate near the surface. Nos. 9. 10, and 11 are also superimposed. In this case there is an increase of organic matter from the surface down. The conditions are almost the reverse of Nos. 6, 7, and 8, though in 9, 10, and 11 none of them is so distinctly sandy. The deepest soil is in this case really the best soil. There is less sand, more organic matter, lime, and sulphuric acid, and less alkalies. The quantity of alkali in all of these soils is about equal to that found in the Rio Grande valley soils; much greater than is ordinarily found in soils devoted to agricultural purposes. But excluding No. 4, the quantity is not sufficient to interfere with their cultivation.

PECOS RIVER WATER.

Below are given two analyses of Pecos River water. No. 1 was collected at Pecos City, and received at the laboratory in January, 1889. Gave an alkaline reaction on boiling, and had alkaline taste. Suspended matter made up largely of red soil, that settled quickly on standing.

No. 2 was collected in Reeves County, and received at the laboratory in December, 1889. Gave, as No. 1 did, an alkaline reaction and possessed the same alkaline taste. Suspended matter made up more of silt and a lighter soil than in No. 1, and settled only after twenty-four hours' standing:

ANALYSES.	Grains per Gallon. No. 1.	No. 2.
Total solid contents	308.48	319.39
Soluble after evaporation	172.59	204.70
Total mineral matter	255.48	259.19
Total lime, as CaO	27.42	37.62
Total sulphuric acid, as SO_3	64.57	76.73
Total chlorine	39.05	65.03
Total alkalies, as chlorides	58.70	106.50
Total potash, as oxide	*	2 95
Total soda, as oxide	*	66.08
Total suspended matter	36.32	85.76

*Not separated.

It will be noticed there is considerable variation in the two analyses; the larger quantity of mineral matter appearing in No. 2. This is particularly true in case of the alkalies. When the last sample was collected the river was lower than in January previous. The total mineral matter is comparatively nearly the same, and very high. Of this the matter soluble after evaporation is also very great.

According to estimates in California, it takes about ten inches of water during a year to perfect a crop. This would probably be the smallest estimate that could be made for Western Texas when judiciously used in irrigating. One gallon of water will cover one and one-half ($1\frac{1}{2}$) square feet one inch deep, or six and two-thirds ($6\frac{2}{3}$) gallons per square foot is equal to ten inches depth of water. If we assume the alkalies in this water to be 58 grains to the gallon, as given in analysis No. 1, on every square foot of soil irrigated from the river there would be brought annually three hundred and eighty-six (386) grains of alkaline chlorides—consisting principally of sodium chloride—on a soil that already contains considerable quantity of alkali. The effect would, in time, necessarily be fatal to the use of the land for agricultural purposes.

It is possible that for a few years the water could be used for irrigation; especially if special crops were grown—those least affected by alkali. But in time there would be sufficient accumulation to destroy plant growth. The water contains some material that is valuable as plant food. The lime and sulphuric acid are in combination as the sulphate, or *gypsum;* this is very favorable to most river-formed soils, and to alkaline soils containing the alkaline carbonates. The river sediment added year by year to the soil would continually enrich it, but for the presence of the *alkalies.*

APPENDIX.

On page 10 Prof. Harrington makes this statement in regard to the effect of alkalies on the growth of crops: "But so far as I can ascertain, the maximum quantity of alkali that any crop would tolerate and still thrive and do well has not yet been determined. The character of the soil would undoubtedly have great influence in this matter." Such being the case, I have delayed the publication of this Bulletin that additional facts might be accumulated bearing upon this point, for it is one of the greatest importance to a large area in the Pecos Valley.

Both before and since the commencement of this examination there has been an experimental farm in operation above Pecos City, using the waters of the Pecos River for irrigation. Upon it have been grown fruits, vegetables, grains, grasses, etc., and the yield has been of such a character, both in quality and amount, as to encourage the construction of canals and ditches and a considerable extension of the irrigation facilities. The claim made by the operators of the experimental farm is that the manner of irrigation prevents the accumulation of the salt to any hurtful extent. The plats are flooded with water and the porous nature of the soil permits rapid drainage. By this means, it is thought by them that the water as it is applied washes out the soluble salt left by former applications, and in turn leaves only about the same quantity as before, as it is drained away or evaporates.

The facts, as I can learn them, are that up to the present, at least, no deleterious effects are noticeable from the application of the water. The crops continue to flourish, and there is no perceptible reason for expecting them to do otherwise while the water continues available as it is now.

That there is, however, an increase in the amount of salt in the land after irrigation is fully proved by the following analyses made of virgin soil and exactly similar soil near it, which had been irrigated for three years. The soils were carefully selected by Prof. W. F. Cummins, and analyses made by Mr. L. E. Magnenat, Chemist of the Survey.

Soil No. 1. Virgin Soil from Section 174, Block 34, H. & T. C. Ry. Co.

Soil No. 2. Unirrigated, Experimental Farm.

Soil No. 2a. Irrigated Soil, Experimental Farm.

Soil No. 3. Unirrigated Soil, Experimental Farm.

Soil No. 3a. Irrigated Soil, Experimental Farm.

	Total Water Soluble.	Sodium Chloride.
Soil No. 1	0.16 per cent.	0.046 per cent.
Soil No. 2	0.23 per cent.	0.044 per cent.
Soil No. 2a	0.38 per cent.	0.074 per cent.
Soil No. 3	0.48 per cent.	0.092 per cent.
Soil No. 3a	1.26 per cent.	0.164 per cent.

While this is true, however, the total amount of sodium chloride which is present in the soil is so small, and the annual addition from the water used in irrigation is so little, that it will require many years cultivation to bring the total amount into anything like a dangerous quantity. Thus, in soil No. 2 and 2a, the increase is only ten thousandths of one per cent annually, and even in the one showing the largest increase, No. 3 and 3a, the difference is only twenty-four thousandths of one per cent, at which rate it would require nearly forty years to bring the total up to even one per cent of the entire soil, an amount which in itself is far below an excess.

Having ascertained this fact by analysis, it then remained to determine the combination in which the large amounts of alkalies, which we have previously found in the soils, existed.

The water soluble matter was first analysed. Solution was effected by heating with water for five days over a water bath and the alkalies determined in the filtrate. The results are as follows:

	No. 1.	No. 5.	No. 6.
Potassium	0.024	0.07	Trace.
Sodium	0.220	0.25	0.11
Sulphuric Acid	0.500	0.60	Trace.
Carbonic Acid	Trace.	Trace.	Trace.
Chlorine	0.27	0.10	Trace.

In the water soluble material, therefore, the alkalies are present as sulphates and chlorides, with traces of sodium carbonate.

The total amounts of alkalies present were then determined in fresh portions by the method of Prof. L. Smith, with carbonate of lime and sal ammoniac, with the following results:

	No. 1.	No. 5.	No. 6.
Sodium	3.23	4.32	4.11
Potassium	2.61	2.77	1.58
Total	5.84	7.09	5.69

Taking into consideration the amounts of sulphuric acid, carbonic acid and chlorine present, as shown in the analyses, it is evident that the larger portion of the alkalies must exist as silicates, since there is nothing else for them to combine with. This is rendered the more certain by the consideration that the rock material from which the soils are derived is largely feldspathic in its nature, consisting of the

intrusive porphyries which cover such an amount of the area West and North of that locality.

With this explanation, the apparent excess of alkalies is shown to be in no wise dangerous to the agricultural prospects of the valley.

The suggestion, however, of growth of crops least affected by alkalies might well be given attention, in so far as by proper rotation of alfalfa and other grass crops which take up larger quantities of alkalies, to keep the amount within proper bounds.

E. T. DUMBLE,
State Geologist.

Feb. 27th, 1892.

DEPARTMENT OF AGRICULTURE, INSURANCE, STATISTICS AND HISTORY.

GEOLOGICAL SURVEY OF TEXAS.

JNO. E. HOLLINGSWORTH, Commissioner. E. T. DUMBLE, State Geologist.

BULLETIN NO. 3.

RECONNOISSANCE

OF THE

GUADALUPE MOUNTAINS.

BY R. S. TARR.

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AUSTIN:
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1892.

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LETTER OF TRANSMITTAL.

DEPARTMENT OF AGRICULTURE, INSURANCE, STATISTICS AND HISTORY.
GEOLOGICAL SURVEY OF TEXAS.
AUSTIN, TEXAS, December 15, 1891.

Hon. Jno. E. Hollingsworth, Commissioner of Agriculture, Insurance. Statistics and History.

DEAR SIR—I herewith transmit for publication the report of Mr. R. S. Tarr on his "Reconnoissance of the Gaudalupe Mountains."

Owing to the amount of material on hand this report, with others, was crowded out of the Second Annual Report in which it was intended to appear and is therefore presented for publication in the form of a Bulletin.

Yours very truly,
E. T. DUMBLE,
State Geologist.

PREFACE

The following pages, descriptive of the results of a trip across Central Texas and into the Gaudalupe mountains, which lie some seventy-five miles west of the Pecos river stretching northwest and southeast across the line between Texas and New Mexico, were intended for publication in the Second Annual Report of this Survey. On account of the number and length of the papers on hand it was necessary to omit several which will be issued as Bulletins.

The work assigned Mr. Tarr contemplated a much more detailed investigation than is here recorded, but circumstances prevented its completion. His return to Cambridge and consequent separation from the materials he had collected on the trip has prevented anything like a complete study of them, and it must be considered, therefore, that the opinions expressed are, as Mr. Tarr says, tentative only, being simply the ideas formed during the field study which, while it was done as carefully as possible, was necessarily of a somewhat rapid character. The facts observed, however, are of considerable interest and add their quota to our knowledge of the topography and geology of this hitherto little known region.

During the present summer further explorations have been made of this range by Prof. Cummins who followed down it from the north. The results of this will be found in his paper in the Second Report of Progress, now in press, and in greater detail in the Third Annual Report of the Survey.

E. T. Dumble,
State Geologist.

RECONNOISSANCE OF THE GUADALUPE MOUNTAINS,

BY R. S. TARR.

INTRODUCTORY.

GENERAL STATEMENT.

The object of this work was to determine the age of the Guadalupe mountains, their geological structure and relation to the strata east of the mountains with particular reference to the artesian water supply of the Plains, and the prospects of the district for coal and other minerals. Circumstances prevented the completion of these plans and consequently the work was done in much less detail than was at first intended. Instead of four months, as was at first planned, only two months were spent in the field and less than one month in the mountains. Furthermore, there being no topographic map of the region and it being impossible to make detailed observations in consequence, the work has necessarily been general rather than of a detailed nature. For these reasons this report is no more than a reconnoissance. Still it has been possible to add something to the knowledge of this region, both of the geology and the economic resources as revealed by the geology.

In order to become familiar with the Permian beds of Central Texas so that they might be recognized, if they existed in the Guadalupe mountains, as reported, it was considered desirable to make a hurried trip across the Permian, thus connecting the Carboniferous area which the writer had previously studied with the Carboniferous of the Trans-Pecos region. In this reconnoissance journey more than a month was spent in constant driving westward and the country from Lampasas to the Guadalupe mountains was hurriedly traversed. The advantage of this in the subsequent work was inestimable. The remaining time at my disposal, less than a month, was spent in and about the mountains.

PREVIOUS WORK IN THE GUADALUPE MOUNTAINS.

The first authentic information about the geology of these mountains came from Dr. George G. Shumard,* who was, in the year 1855 appointed geologist to the expedition under Capt. John Pope, of the U. S. A., ordered by the War Department to test the practicability of obtaining artesian water on the plains of Texas and New Mexico. This eminent geologist and explorer described quite accurately, as was his custom, the region which he traversed, and there are but few points in which my observations, in any essential particular, disagree

*Observations on the Geological Formations of the Country between the Rio Pecos and the Rio Grande, etc., G. G. Shumard. Trans., St. Louis Academy of Sciences, 1858, pp. 273–289.

with his made thirty-five years ago. This paper is in the form of a detailed report of the geologic features of the route followed. His full report was not published by the War Department, but in the year 1886, this was published by the Department of Insurance, Statistics and History of the State of Texas.*

The first announcement of the supposed Permian age of the Guadalupe mountains is made by Dr. Shumard on p. 277 of the Trans. St. Louis Academy of Sciences for 1858, the announcement being based on the paleontologic researches upon his collections by Dr. B. F. Shumard. The latter announces† the Permian age of the Guadalupe mountains by the description of new Permian fossils.

Later another paper‡ based upon the same collections gives a list of all the fossils obtained, many of which are announced to be identical with Permian fossils from Europe and Kansas. Since then I know of no publication which refers these mountains to the Permian age.

Prof. Jules Marcou, in the year 1858, published his geological map|| in which the mountains are colored Carboniferous.

A review of the papers published by Dr. B. F. Shumard, expresses§ some doubt of the conclusions arrived at by Dr. Shumard.

Nothing has appeared since then so far as I know except a paper by Walter P. Jenney, briefly describing some geologic features of the south end of the mountains along the route travelled. Without giving reasons, he speaks of the rocks as Carboniferous.**

There is in the archives of the Geological Department at Austin a manuscript report by Dr. G. G. Shumard upon the artesian water supply of the region east of the Guadalupe mountains. My results agree almost directly with his. This report was never published by the War Department, nor was his advice heeded, but much money and time were wasted in a futile search for water contrary to it.

I have divided this report into two sections. First. A brief statement of the reconnoisance of the Central Texas Permian. Second. A description of the geology of the Guadalupe mountains.

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*A Partial Report on the Geology of Western Texas, etc., by Dr. Geo. G. Shumard, Assistant State Geologist of Texas, p. 145, Austin State Printing Office. 1886.

The portion particularly referring to the Guadalupe Mountains and vicinity is in Chap. V., pp. 88-96.

†Notice of New Fossils from the Permian Strata of New Mexico and Texas. B. F. Shumard, Trans., St. Louis Acad. Sciences, March 8, 1858.

‡Notice of Fossils from the Permian Strata of Texas and New Mexico. B. F. Shumard, Trans., St. Louis Acad. Sciences, 1859.

||Geology of North America. Zurich, 1858.

§American Jour. Science, Vol. XXIX., 1860, pp. 125-126, signed "M."

**Notes on the Geology of Western Texas near the 32d Parallel. Walter P. Jenney, Am. Jour. Science, 3rd series, Vol. VII., Jan., 1874.

PART I.

RECONNOISSANCE SECTION ACROSS THE PERMIAN OF CENTRAL TEXAS.

In the section made by the writer during the winter of 1888-89, across the Central Texas Carboniferous area of the Colorado Valley the section ended a few miles northwest of Coleman, where the Carboniferous is covered by Cretaceous. The Carboniferous is there dipping gently northwest while the Cretaceous lies uncomformably with a very gentle southeast dip. The Carboniferous beds at the point where they are covered by the Cretaceous, belong to the Coleman division and consist of mottled and vari-colored clays interbedded with limestones containing considerable clay. A description of these beds appeared in the First Annual Report.

ROUTE FOLLOWED.—From the point where the last section ended I travelled northwest to Abilene and thence W. S. W. along the line of the Texas & Pacific R. R. to the Pecos river, a distance of 279 miles. With the exception of certain small Cretaceous areas and some beds of Carboniferous between Coleman and Abilene, the strata along this route are all Permian.

CRETACEOUS AREAS.

The first of these Cretaceous areas was seen northwest of Coleman where it forms a divide between the head-waters of the south branches of Jim Ned creek and some small creeks directly tributary to the Colorado river. It is a very much degraded area consisting chiefly of beds of the Trinity division capped in the higher parts by limestones of the Comanche series. On the southeast side the base of the Cretaceous is 1930 feet above sea level but three miles northwest the contact between the Cretaceous and the Carboniferous is found at an elevation of 2025 feet.

Cedar Gap is a pass in the range of Cretaceous buttes formed by the combined erosion of two creeks, one tributary to the Colorado and the other to the Brazos. A range of these Cretaceous buttes or mesas extends from near the Colorado eastward, several miles beyond Cedar Gap and mark the divide between that river and the Brazos, and are remnants of the old Cretaceous plateau remaining in degraded form in the region of slow erosion, or at the head-waters.

Above the general level of the gap, in the lowest part of the butte are about twenty-five feet of red beds, evidently Permian. Above this are one hundred feet of Trinity Sands capped by twenty-five feet of thick bedded limestone (Comanche series). The lower Trinity beds are yellow and gray sands and clays with a considerable admixture of red clay. This red clay is so abundant as to give the lower part of the buttes

on both sides of the gap a distinctly red appearance, thus giving additional evidence to the extremely local derivation of the varying Trinity beds.

From Big Spring westward for one hundred miles the geological structure is undoubtedly Cretaceous though in a few small isolated patches the Permian may come to the surface. The first indication of the undoubted Cretaceous is in a railway cut two miles east of Big Spring. A small syncline here exposed in section has a southeast axis and a dip in one place as great as ten degrees southwest and five degrees northeast.

The width of the syncline is not more than 100 feet in the exposed section.

Beginning at the base the section is:

Dark red cross-bedded sandstone	3 feet
Red sandy clay streaked with white	1½ to 3 feet
Dark red, very much cross-bedded, sandstone, slightly conglomeritic .	4 feet

Conglomerate grading into the lower sandstone, and composed of pebbles generally as large as a nutmeg and larger. Pebbles are quartzite and other metamorphic rocks (hornblendic, etc.,) and considerable limestone, resembling that of the Coleman division. The small pebbles are generally well rounded, but the larger ones are often quite angular. The cement is limy and in places magnesic.

This conglomerate resembles quite closely the Trinity conglomerate of the Cretaceous, and it may belong to this age. Several specimens of oysters were found in the conglomerate, but they are in such a poor state of preservation that it is quite impossible to determine them.

On the railway, 2½ miles west of Big Spring, there is a cut in an impure clayey greensand, from which bones were collected. No other fossils were found in this vicinity. Above this sand is a yellow sand overlaid by an unfossilliferous magnesic limestone. Chiefly from the character of the overlying beds I conclude that this stratum is a member of the Trinity division of the Cretaceous, and this conclusion is rendered the more probable from the occurrence of the oyster-bearing bed beneath it east of Big Spring.

CRETACEOUS NEAR MARIENFELD.

The strata in the bluffs bordering the valley of Girard creek have a general reddish hue toned down in intensity by lighter colored sands. These may be Trinity beds with a red color derived from the underlying Permian, though of this I can offer no definite proof.

From this point westward the country is a gently undulating plain without any abrupt rises or marked hills, but with a general ascent westward. There is little to indicate the geological structure in this section, but the soil is sandy, and it is probable that the strata exposed in Girard creek continue for this distance. Three miles east of Marienfeld a peculiar mottled limestone appears above the sand. It has a

very pretty marbled appearance due to concentric rings of white and pink, the latter being no doubt derived from an oxide of manganese. As it is very soft and fades in the sun, it is probable that this will not be of any value in the arts, although in a fresh piece it is very beautiful. Above and below it is a reddish sand. No fossils were found in this rock. In some cases it contains small scattered conglomeritic pebbles. This resembles, in certain respects, a banded alabaster appearing above the Carboniferous near the head of Delaware creek on the west of the Pecos, and may be a contemporaneous, or, perhaps, a continuous stratum.

At and near Marienfeld, particularly west of that town, a comparatively pure stratum of water is found at moderate depth (45 feet, differing according to location) beneath this limestone in a stratum of sand. It is not artesian, but is pumped by windmills. Indeed, there is a water-bearing stratum at about this horizon for many miles west of Marienfeld. As it is cut on the east and west by deep valleys, and as the surface of the country is above the source of water supply, no artesian water is to be expected in or near this bed.

West of Marienfeld the bed rock appears from the soil to be entirely limestone and sand pebbles finely conglomeritic in places. The limestone first encountered east of Marienfeld still continues, outcropping occasionally but always unfossiliferous. The persistence of this layer for thirteen miles on a country sloping eastward seems to indicate an easterly dip, though a very slight one. At the section house at Germania, ten miles west of Marienfeld, an oyster bearing bed is found above the banded gypsiferous limestone. At the Warfield section house, twenty miles west of this, another gryphaea bed is found, possibly the same as that last mentioned.

Numerous sink holes occur between Midland and Odessa indicating that probably here is one chief source of supply for the water contained in the water bearing stratum so frequently encountered hereabouts.

The undulating prairie ceases about five miles east of Metz, ending abruptly in a somewhat degraded mesa bluff facing westward and this is the eastern boundary of the Pecos valley along my line of section. Douro, the highest point on the T. & P. R. R. east of the Pecos, is about 3100 feet above sea level and 500 feet above the Pecos River. It is on the divide between the Pecos and Concho but there is much country hereabouts which is almost entirely without surface drainage.

At Douro there is a gryphaea bed made up almost of these fossils. The section exposed on the face of the bluff west of Douro is approximately as follows, beginning at the top:

Marbled magnesic limestone, unfossiliferous.
Gryphaea Pitcheri (?) beds.
Unfossiliferous limestone much discolored by iron.
Very fosiliferous limestone, rusty.
Sandy limestone.
Sand, yellow and red in places.

The total thickness from one to five inclusive, is about 150 feet, but the thickness of the sand was undetermined. The fossiliferous limestone beds, except the gryphaea beds were not detected farther east, but this is not strange since the greater part of the country is covered with a deep residual soil.

From the base of the mesa bluff just east of Metz to beyond Monahan, a distance of nearly twenty miles, the Trinity sands cover the surface in the form of sand dunes. This strip of sand extends many miles north and south averaging in width from twelve to fifteen miles. It is a striking development of blown sand and with every breeze the sand is shifting position. The conical hills, and crater like pits so typical of similar æolian deposits, are strongly developed here where they are rendered possible by the aridity of the climate and the presence of an abundant supply of sand furnished by the Trinity beds, as the bluff recedes and partly protected from removal to the eastward by this high bluff. The sand is chiefly white, having been bleached during its long exposure to sun and wind and is scantily clothed in places by such native plants as greasewood, sagebrush, mesquite, cactus, soapplant and sandgrass. These in part hold the sand in place, but only partially so, since in this region every moderate breeze carries along clouds of sand before it.

CARBONIFEROUS.

COLEMAN BEDS.—Where the Trinity beds disappear, northwest of Coleman, the Coleman beds of the Carboniferous are found beneath them. At this point there is a blue, very much rusted, clayey limestone containing many specimens of a large *Pinna*, *Myalina*, *Bellerophon* and *Bryozoa*. One *Pinna* on a slab near the road had a length of 23 inches, with a greatest width of 3 inches. A portion of the small end was gone.

The region hereabout is but recently uncovered by the erosion of Jim Ned creek. In the valleys the Carboniferous rocks are exposed, but to the north and west, as well as south, hills and buttes are found. Some of the hills from which most of the Cretaceous has been removed are still partly covered by small patches of Trinity Sand.

The character of the Carboniferous rocks is identical with that described in the report on the Carboniferous under the head of the Coleman beds. There seems to be very little clay, but its apparent absence may be due to the talus covering formed by the down dropping of the limestone on the hill sides. This feature is quite typical of the

Coleman beds in other sections, the bluffs being on the outcrop (S. E.) side, and the chief erosion being that of the soft clays and the consequent breaking down of the harder limestone layers. This process has entirely obscured thick and numerous beds of clay where other evidence has proved their existence. Furthermore much of the exposed Carboniferous has not suffered extensive denudation, since it has been only recently uncovered.

The fossils of these beds are not varied in the number of forms, but some beds contain a great abundance of individuals belonging to such groups as *Pinna*, *Myalina*, *Bellerophon*, and certain *Bryozoans*. Everything indicates that fossils fitted for hardy life were the only ones to flourish under the conditions that then existed. A specimen of *Pleurophorus*, found just northwest of Coleman, points to the approach of Permian times.

TRANSITION FROM CARBONIFEROUS TO PERMIAN.

Just northwest of the fork of Jim Ned creek the approaching change from Carboniferous to Permian previously indicated by the change in fauna receives further confirmation by a lithologic change. The dip of the strata, however, appears to remain unchanged. No unconformity or overlap appears in this line of section, and if such phenomena exist, they can be detected only by continued work along the line of contact. One would infer from all the evidence that appears in the single section traversed that the red beds of Central Texas directly and conformably succeeded the Carboniferous with a line of contact that must be arbitrarily drawn. Certainly, however, the Permian is foreshadowed in the Carboniferous and in the Permian, relics of the Carboniferous are found, so that the break, if any existed, was small indeed.

The Permian in its best development is in nearly every way distinct from the the typical Carboniferous and in many ways from the upper beds of the Carboniferous. There is only a tract of a few miles in breadth about which any doubt can be entertained. The beginning of the Permian epoch was indicated in Central Texas at the close of the deposition of the beds of the Brownwood division. The seashore deposits of the Waldrip division with its accompanying bed of coal apparently marked the beginning of the great inland sea which reached its best development in Permian times. Throughout much of the Coleman strata seashore deposits reappear at frequent intervals as the section is studied upward and everywhere the presence of an abundance of clay is indicated. The faunal features still remain Carboniferous throughout the Coleman beds, but the life is in many ways different from that which existed during the deposition of the Brownwood beds in the clear deep water.

The apparent transition stage between Carboniferous and Permian

begins one half mile northwest of the south fork of Jim Ned creek. Here a bed of red sandy clay forty feet thick appears both overlaid and underlaid by a rusty clayey limestone. This in itself in no way differs from similar beds observed southeast of this in the typical Coleman, but this marks the beginning of a change in which finally nearly all the beds assume a reddish hue. The transitional beds should probably properly be classed with the Coleman beds of the upper Carboniferous, and the whole Coleman series may be possibly classed as Permo-Carboniferous.

TYPICAL PERMIAN.

A few miles northwest of the south fork of Jim Ned creek appear thin bedded shaley, red sandstones and red clays with geodic concretions.

From this on to Abilene the soil is everywhere of the peculiar red Permian hue. Occasionally limestone fragments indicate the proximity of this rock to the surface. It is invariably magnesic and in the creek bed six miles south of Abilene there is a typical exposure of the clayey pure white dense magnesic limestone of the Permian.

A deep red soil covers nearly all the country, derived no doubt by the wash from the abundant Permian clays. In places the soil is a fine grain sandy conglomerate, possibly derived from the decay of some Trinity conglomerate, but more probably from the decay of Permian.

From Abilene my course followed approximately the Texas & Pacific railway first a little north of west, then west-southwest to Pecos City.

Around Abilene and westward for six miles no bed rock outcrops, but the country is a comparatively level, deep soil prairie covered with mesquite. The soil is chiefly a sandy fine grained conglomerate. Seven miles west of Abiline near the railway there is an outcrop of Permian conglomerate and it is very likely from this bed that the soil to the east is derived. Fossils were collected in a bluish gray clayey limestone eleven miles west of Abilene in a railway cut. The fossils belong in the genera *Pinna*, *Myalina*, *Productus*, *Bellerophon* and *Lima* (?). They appear to be in no way different from the fossils of the Coleman division.

The level country continues westward to Merkel, twenty miles west of Abilene, but at this point the prairie character is lost and is succeeded by hills. This change has been brought about by the erosion of Sweetwater creek and other branches of the main Elm Fork of the Brazos. This change commences just west of Merkel where the east facing mesa rises to a height of more than seventy-five feet. The face of the Merkel mesa exposes alternating red and white strata of clays, sandstones, conglomerate and limestone. A peculiar purple conglomerate appears near Trent, consisting of sandy and breccia layers with a purple cement colored probably by maganese.

As far as Merkel and eight miles west of this the water in wells is of good quality, but at the latter point the character of the water changes and gypsum water begins to be found. Just beyond this, one and one-half miles west of Trent is a gypsiferous pulverulent white limestone with occasional (generally small) pebbles. Just west of Trent a small bluff reveals alternating red and white (gypsum) beds overlaid unconformably by recent conglomerate.

From Trent to Sweetwater, a distance of ten miles, the country is very rough being either much cut up sandy mesquite flats, or hills with a surface coating of recent conglomerate. The soil is chiefly reddish, but most of the rock outcrops are of white pulverulent limestones. Two miles west of Trent there is a stratum of gypsum, and gypsum is also associated with the white limestone in thin bands and layers. Near Sweetwater in Sweetwater creek there are alternating strata of red clays and white gypsiferous beds. No fossils were noticed in any of these beds.

From Sweetwater westward, the country rises quite rapidly for eighteen miles, this being the divide between the Colorado and the Brazos. The divide at the point crossed is a nearly level prairie with some mesquite, but in large measure without any brush growth. While apparently quite level, it slopes gently eastward, though no drainage is apparent for a distance of four miles east and west. This is succeeded westward by gently rising land to the top of its divide when the gentle eastern slope is succeeded by a rapid descent into the valley of the Colorado. In less than three miles the descent is two hundred feet. Beyond this the slope is more gradual, but from the top of the divide to the bed of the Colorado, the country is much broken, being there very different from the country on the Brazos side of the divide.

Between Sweetwater and Loraine, few outcrops occur, but the surface is chiefly sandy and conglomeritic, its soil always having a reddish hue. Three miles west of Sweetwater there is a conglomerate with a very limy cement closely resembling certain Trinity conglomerates in Brown and adjoining counties The pebbles are quite angular and often large, sometimes weighing several pounds. These pebbles are chiefly limestone and many of them resemble the Coleman and the Brownwood limestone. There are also limestone pebbles closely resembling the Silurian rock of San Saba county. Certain flint pebbles aid in this resemblance, but no fossils have been found in them. It seems difficult to account for the presence of these large, quite angular pebbles so far from any known outcrop.

It is quite probable that this and other similar conglomerate layers are the source of supply for the abundant recent conglomerate here and at various places east of this point. This common conglomeritic

soil may have been derived either from residual decay or transportation or more likely from both causes combined.

At Colorado City, on the Colorado river, there is a great development of sandstone and conglomeritic sandstone appearing both in the broken hills and bluffs and as a residual soil on the surface. A well bored to the depth of nine hundred feet at Colorado City passes chiefly through sandstone to a stratum of water which rises to within two hundred feet of the surface. A bed of rock salt encountered in the boring changes the water to a brine and this is pumped to the surface and used in the manufacture of salt.

Throughout much of the sandstone there is some salt, and in a creek bed four miles west of Colorado City the water is saline.

The dip of the Permian strata has been uniformly northwest but at a decreasing angle. So small is the angle of dip that it is almost impossible to tell in which direction the rock is tilted, and this difficulty is increased by the peculiar nature of the beds. many of which are so easily eroded that the exact outcrop edge is either very irregular or entirely covered. Near Colorado City the strata are so nearly horizontal that I have been unable to make any determination of the direction of dip.

DOUBTFUL BEDS NEAR WESTBROOKE.

The mesa country commences just west of Westbrooke in the valley of the Colorado. At this point a gentle undulating prairie is succeeded westward by a mesa with broad prairie-like top and with abrupt faces on the southwest side. Here the beds are chiefly red clay with bands of red shale and some thin limy layers. The lithologic appearance of this country is so much like the Permian farther east that one would not suspect that there was a possibility of its being of a different age. The occurrence of selenite crystals in the clay is worthy of note. The abundance of clay in these beds is quite noticeable in distinction to its absence in the upper beds of the Permian just passed over.

At Iatan, another more marked mesa facing eastward is encountered. A broken wall varying from fifty to one hundred and twenty-five feet in heighth extends in a general north and south course. The lower seventy-five feet of the mesa wall consists chiefly of red clay with occasional bands of red shale and sometimes bands of limestone. This is overlaid by twenty feet of white sandstone very much cross bedded, the layers in some instances dipping at diverse angles as high as ten or fifteen degrees. This sandstone is limy with occasional small pebbles. Above the sandstone on the top of the mesa is twenty feet of a remarkable quartzitic comglomerate very hard and flinty, quite compact, and breaking into angular pieces. It con-

tains many small pebbles, generally less than the size of a pea, though with a few as large as a nutmeg. The cement is in places magnesic.

The Iatan mesa appears to dip as much as two degrees S. E., and a southeast dip has been quite noticeable since leaving the Colorado.

Between Iatan and Big Spring the surface of the country undulates considerably with a general rise to the west to within six or seven miles of Big Spring, when the valley of Girard creek, a large branch of the Colorado, is reached. The soil is chiefly sandy with some red clay. Near Girard creek the soil is very sandy, the sand being derived from a calcareous or magnesic white sandstone, which outcrops for some distance east of Big Spring. To the south and west are a series of buttes and mesas, the most remarkable of these being Signal mountain on the west side of Girard creek. This butte, apparently perfect in outline from any view, stands out as an outlier entirely isolated from the mesa. From the base of the mesa, south of Big Spring, a great body of constantly flowing water comes to the surface, forming the water supply of that town.

While the conglomerate east of Girard creek is plainly post Permian and probably lower Trinity, and the beds described west of the creek are probably of corresponding age, it is quite possible that the white sands of Girard creek are still Permian.

EROSION AT SOUTH BORDER OF LLANO ESTACADO.

The type of erosion west of Big Spring is interesting. Girard creek, so called, is not a creek in any sense of the word. There is a broad valley, but without extraordinary floods water cannot flow in it. For six miles the railway follows up this valley, then the valley turns northward into the Llano Estacado. The average width of the valley is not more than a mile, and the borders are more or less degraded bluffs, sometimes quite abrupt, and generally from 50 to 100 feet in height. There is no channel, but here and there a lagoon, generally no more than a bog or an alkaline flat without vegetation of any kind. The valley has apparently been deeper, and it is now filled with sediment probably in part brought down from time to time whenever excessive rains furnish water enough to permit of its flowing, as I am informed is sometimes the case. Much of the detritus with which the valley is at present clogged is derived from the neighboring cliffs in time of rain, and is deposited in the form of local and temporary deltas. The general appearance of the valley is that of a shallow estuary in the marshy country of the seacoast of the northeastern states. This resemblance is increased by the presence of barren flats without vegetation and the presence in places of a coarse salt grass, whose habitat is a damp clayey alkaline soil. Much of the valley is occupied by low mounds (cone deltas) and mesquite flats, and one would not suspect that water ever flowed in the valley.

How to explain this comparatively deep valley, and the clogged up channel is difficult. The stream, when one flows, is plainly overburdened. In some way it may be connected with the Quaternary lake deposits of the Llano Estacado. It may even be a case of reversed drainage, or, if not, a valley formed in times when the water supply was greater than at present.

South of Big Spring the valley is quite different, being here cut into the bed rock not only in the channel proper but runs into the surrounding country. The sharp erosion at this point indicates a young drainage and it seems very much as if the headwater erosion of a rejuvenated stream was now employed in removing the detritus with which the stream bed has been clogged in earlier times. The Concho river farther west is a similar instance of this peculiar drainage.

PROBABLE PERMIAN NEAR PECOS CITY.

Beyond Arroya rocks appear, the geological position of which I am unable to give. These are white limestone, weathering chalky white. They may be a part of the lower Trinity.

Beneath these, near Quito, east of Pecos City, a compact well-jointed red sandstone occurs, dipping gently southeast. This, I believe, to be Permian, though I can offer no definite proof of this, since there are no fossils and I have not studied their relation with beds above and below which may be possible further south.

A company recently organized has commenced developing this sandstone, which promises to be one of the best in Texas, and to rank well with the building stones of the west. It is of a beautiful red, uniform in color and texture, easily worked, yet durable and in every way adapted to the best uses in building. Considerable stone has already been contracted for The company was, at the time I passed, engaged in boring a well which had already passsed through one hundred feet of red sadstone. This, coming as it does, below what appears to be the base of the Trinity, seems to indicate a Permian age.

PART II.

GEOLOGY OF THE GUADALUPE MOUNTAINS.

GENERAL STATEMENT.

For reasons which will appear later, I believe the Guadalupe mountains to be carboniferous in age contrary to the opinion of the Shumard Brothers, the only other geologists who have ever studied the mountains *

The lower rocks are yellow, clayey sandstone, with beds of black limestone, in places almost a slate. The middle beds are thick bedded fossiliferous white magnesian limestone and the upper beds sandstone chiefly. These will be described in more detail later. No Permian beds appear between the Guadalupe mountains and the Pecos in the section studied, but wherever the Carboniferous is coverēd by later formations these deposits are either Quarternary or Cretaceous. In the mountains proper, the rocks are all Carboniferous, but on the northern end in New Mexico Cretaceous beds exist in the foot hills, and from this point a scarp of Cretaceous rocks covers the Carboniferous at a progressively increasing distance toward the southwest being, at the head of Delaware creek, about twenty miles from the base of the mountains. Quarternary conglomerate appears both on the Carboniferous and Cretaceous at places.

TOPOGRAPHIC FEATURES OF THE GUADALUPE REGION.

The chief part of the Guadalupe mountains lie in New Mexico, and this end was visited only in so far as was necessary for a correct understanding of certain general features.

The general form of the Guadalupe mountains is prow shaped. Commencing in New Mexico, at a moderately low elevation and more than twenty miles wide, they become progressively higher followed southward, at the same time becoming narrower until the point of the mountain is reached. This, the southern part, is just south of Guadalupe Peak the highest point, which is eight thousand feet above sea level. The point of the mountains is a precipice in the white magnesian limestone fully two thousand feet high which suddenly terminates the mountains. South of this the line of disturbance is continued in the form of foot hills with an abrupt face to the west.

On the northern end in New Mexico the mountains continue for many miles becoming progressively lower until they are really no more than foot hills. The dip of the strata in the mountains is very

*Mr. W. P. Jenney speaks of them as carboniferous, but without giving reasons. Mr. Jenney's report to the railway company has never been published, and merely a brief mention of the mountains appears in his paper Am. J. Sci., 1874, previously mentioned.

nearly east on the average, being in some cases N. 70° E. At places the amount of dip is widely different, but in general it is from three to five degrees a few miles away from the mountains and become in some cases twenty to thirty degrees in the heart of the mountains. The ~~direction~~ of dip is quite variable locally because of numerous small folds. The Guadalupe are monoclinal in structure, the ~~dip being~~ diagonal to the eastern exposed face. That is, the mountains as seen from the east trend N. E. by N. while the dip is N. E. by E. This, therefore, accounts for the progressive increase of elevation southward as well as the rise to the westward, in other words, it accounts for the mountains as seen from the east.

A gradual increase of dip westward to the heart of the mountains is then followed by a general decrease in amount of dip, and this gentle easterly dip on the west face of the mountains quickly, in two miles, and in some cases even less, changes to a sharp westerly dip, in some cases as high as thirty degrees. Numerous small faults and folds were detected in the area, which has a linear extension in the region examined of at least twenty-five miles. A valley marks this apparent anticlinal crest for the entire distance and occupies the site of what I believe to be a great fault. The evidence both for and against this hypothesis will be given later. On this basis the Guadalupe mountains are considered to be a Carboniferous monoclinal fold dipping eastward and terminated to the west by a great north and south fault. The anticlinal appearance being due to dragging up of the strata on the downthrow side. These points are mentioned in this place on account of the bearing which they have upon the development of the topographic features; but their discussion is reserved for the chapter upon the geologic structure.

Sharp and rapid erosion has deeply carved these hard rocks. One of the most striking features is the remarkable roughness of the mountains and the innumerable great precipices everywhere existing in the mountain canons. There are hundreds of distinct precipices over a thousand feet high. nearly vertical. These are observed in every canyon and many large gorges heading in the interior of the mountains. This feature is rendered possible not alone by the youth of the drainage and the massive hardness and uniformity of the magnesic limestone forming the greatest part of the center of the mountains, but also by the character of the joint planes which are strongly developed to great depths. Possibly, also, fault lines may have aided in this, but of these I have found no evidence in any part of the mountains, except the western face.

DARK CANYON.

The Guadalupe mountains are drained by five important creeks, three of which flow eastward into the Pecos and two westward into the

Crow Flat Valley, where any water that they may ever carry is lost. The easternmost of the east flowing tributaries is Dark Canyon, which heads well up toward the Texas line and flows a little north of east through New Nexico into the Pecos. Everywhere in the mountains and in the foot hills beyond, this creek has for its valley a precipitous canyon. There are several small springs in its course, but it carries no flowing water. From a ranchman living in this valley I learned that for three years the creek, in its middle course, had never carried flowing water. Yet that it sometimes does carry running water in the form of great floods is attested to not alone by the depth of its valley, but by the vast number of large well rounded pebbles with which its channel is littered.

BLACK RIVER.

The next creek southward toward the point of the mountain is Black river, rising by a number of tributaries in the mountains and flowing about North 70° East along the dip of the rocks to the Pecos. There are several canyons of importance among its mountain tributaries, but the southwesternmost, McKitterick canyon, is the most important, and may be taken as a type of the mountain streams in the Guadalupes.

MCKITTERICK CANYON.

At the base of the mountains, near the mouth of McKitterick canyon, this stream has a moderately deep valley with quite precipitous sides. From this point the canyon becomes rapidly rougher, proceeding upstream, and at a distance of two miles from its mouth it is inaccessible to wagons. In a very short distance it is inaccessible to a horseman, and is traversed on foot only under great difficulties. About one and one-half miles from the mouth the canyon forks, and it is by the southernmost of these two forks that the greater part of the Texas end of the mountains is drained, while the northern branch drains a great area in New Mexico. These two forks, one from the south the other from the north, flow nearly parallel to the trend of the mountains, and meet at an angle of about 125 degrees, then the stream cuts through the mountains to the plateau on its way eastward to the Pecos. Irregular in course in the mountains, and with many small tributary gorges, these two forks of McKitterick canyon have done much toward sculpturing the mountains into their present form, and have thus acquired a large and very much broken drainage area.

The hill gorges and canyons in this drainage area are scantily timber covered. A general absence of soil and the aridity of the climate are adverse to any other condition. Yet in the canyons, sheltered from the sun, and upon the higher hills and valleys, much pine and cedar timber is found. Other vegetation is very scanty, and of the usual arid land types, so that upon the steep slopes there is little or no pro-

tection to soil that might have a tendency to form under more favorable circumstances.

Although in the midst of a truly arid region, the elevation lifts the general mass of the mountains above this condition into the subhumid belt. Several months are liable to pass without rain, but during May, June, July and other warm months the higher parts of the mountains are frequently capped with rain clouds, and the rain gathered in there often falls well out upon the surrounding plateau and foot hills. During the winter the mountains contain considerable snow, which in the higher and more protected canyons lasts sometimes as late as the middle of April.

During excessive rains the creeks carry water to the Pecos, but this is very rare, and for the greater part of the year the plateau channels are simply dry creek beds; but that they are simply sleeping giants is proved by the broad channels filled with large pebbles and even boulders of white limestone, whose only source of supply is the heart of the mountains often several miles distant.

Numerous springs in the main canyon and its tributary gorges in the mountains furnish a supply of pure clear water, which flows nearly to the mouth of the canyon, where it sinks into the gravelly creek bed.

All along the canyon and its tributary gorges hills of circumdenudation rise abruptly to an elevation often exceeding 2000 feet. The slope is rarely less than 30 degrees, and frequently there are grand perpendicular walls almost vertically rising from 1000 to 1800 feet above the talus. All of the larger precipices are in the massive white limestone. Many of the mountain peaks are absolutely inaccessible from the canyon, and all are ascended only with great difficulty.

This is a young mountain stream, and has been a very active one. This is shown not alone by the rapid fall in the channel and the wonderfully precipitous sides, but also by the presence of a cemented conglomerate, a remnant of the old stream bed, found in fragments clinging to the side of the canyon upon the limestone wall, in one case fifty feet above the base of the channel. The climatic conditions greatly favor rapid erosion in spite of the fact that very little rain falls. One mountain torrent will remove in a few hours more detritus than could be removed in many months by water which collects in a stream by the ordinary rains of a humid climate. Another factor is, of course, the great elevation above base level. Then also the ordinary processes of sub-aerial denudation act strongly in such a region, and the chief work of erosion is the down cutting of the channel, which is not retarded by the necessity of removing a load imposed upon it by the wasting away of the valley sides.

The great amount of rock removed in McKitterick canyon alone cannot be appreciated. The valley for five miles will average 1000 feet deep and one quarter mile wide at the base, increasing in width at an

average angle of 35 to 40 degrees toward the top. To this must be added innumerable small and large tributary gorges, all of which are and have for a long time been at work sculpturing the mountains. All of this has an important bearing upon a geologic feature to be noticed later.

The great floods which sometimes flow from these mountains are not only laden with sediment, but roll along quantities of pebbles, in some cases more than 100 pounds in weight. Reaching the plateau, and thereby coming to a region with a smaller angle of slope, the overburdened stream can carry the load no farther, and there it is deposited in or near the channel. These stream channels near the mountains are sometimes a quarter of a mile wide and completely littered with pebbles. This is, I believe, the true cause of origin of some of the Quaternary and recent conglomerates on the plateau. Indeed, in some cases it is undoubtedly so.

Another important factor among these mountain streams is corrosion. All the springs are impregnated with lime, and in a short distance, on flowing over the limestone bed, the water becomes saturated. Shortly becoming overcharged by evaporation, the lime is deposited, and much of the bed of the creek in McKitterick canyon in its lower course has a tufaceous deposit by which pebbles, leaves and sticks are cemented together into a stream bed conglomerate. Much of the conglomerate in the plateau east of the mountains has a similar cement. Thus in the lower two or three miles this mountain brook flows in a cemented pebbly bed, while in the upper course it runs upon irregular rounded bedrock, which it is rapidly eating up by chemical solution.

Corrosive work is also noticed on the hill sides, where the "mountain type" of corrosion is well shown. It is so called on account of the simulation by chemical solution of a relief map of a mountain chain with its gullied ranges and parallel valleys. In the Carboniferous limestone the ridges are rarely more than two or three inches apart, and the valleys not more than an inch in depth. This added to the projection of fossil remains produces a very rough surface. So hard and rough are all the weathered rocks that they are called granite and porphyry by the ranchmen, and compared in cutting power to glass.

Owing to the steeply sloping sides and the hardness of the white limestone there is very little soil anywhere in the white limestone region, but everywhere the surface is strewn with angular corroded fragments of rock.

While McKitterick canyon has gained possession of much of the drainage area of the center of the range other small branches are engaged in a struggle for territory on the eastern face. For several miles south of the Texas line there is a narrow ridge which, from the east, appears to be the highest part of the mountains at this place. It is nearly 8000 feet high and 2500 feet above the base. This is the

divide between some small northwest flowing gorges tributary to McKitterick canyon and some east flowing gorges tributary directly to Delaware creek. The divide is for some distance (about two miles) a narrow, rocky ridge, often not more than five feet wide. On both sides of the ridge is a small precipice rapidly crumbling down and falling as a talus. In this way the ridge is rapidly losing elevation.

PINE CANYON.

A tributary to Delaware creek, Pine canyon, south of McKitterick canyon, is the only other branch of any importance tributary to the Pecos. It heads in or near the base of Guadalupe Peak, and it is the erosion of this creek which has given to this part of the mountain its sharply defined topographic relief—a feature which is rendered possible by the high elevation of that region. The description of McKitterick canyon applies in all its essential features to this stream.

DRAINAGE ON THE WEST SIDE OF THE GUADALUPE MOUNTAINS—DIFFERENCE BETWEEN THIS TYPE AND THAT ON THE EAST SIDE.

The east face of the Guadalupe mountains, while rugged and steep, is in very few places inaccessible. The northern end is low and not difficult of access, but as the high southern end is approached the ascent becomes more and more difficult, and at the precipitous Point it is impossible to reach the top. Furthermore, the eastern side is cut by gorges and canyons, some of which, as has been described, reach well into the heart of the mountains. The base of the mountains is not bordered by foothills, as is frequently the case in similar ranges, but eastward to the Pecos is a plateau with a quite rapid descent in that direction.

This plateau is carved into hills and valleys by stream erosion, but is not excessively broken. The slope both of the plateau and mountains on the east in general corresponds with the dip of the underlying rocks.

On the western side, however, a difference in geologic structure has produced a difference in topographic character. The western face is precipitous and inaccessible wherever the white limestone outcrops on that side. Furthermore the sharp western dip of the rocks at the base of the mountains on that side has rendered the existence of a series of foot hills in this region possible, and their condition has been favored by the existence of a valley marking the approximate site of the line of geologic weakness. This line, whether fault or fold, is now marked by two valleys in the region which I have studied. One, Guadalupe canyon, on the south, heads in two forks, one on either side of the precipice called "Point of the Mountains." A spring exists near the head of the northernmost of these, but neither fork carries running water for any distance at ordinary times. It seems an

inadequate cause for the remarkable precipice, and I am inclined to explain it by other causes than recent erosion. This explanation will appear in its proper place. The drainage of this canyon is into Crow Flat valley.

DOG CANYON.

Dog canyon, the only other stream of importance draining the west side of the Guadalupe mountains in this section, heads very near the headwater of the southern fork of the Guadalupe canyon and at the western base of the point of the mountains. It certainly seems impossible that this small stream, in which no spring even exists, could have carved the precipitous western face of the mountains into its present form and removed all the rocks that are absent. This seems still more impossible when compared with the amount of erosion done by better armed streams on the eastern side. Dog canyon, after flowing parallel with the face of the mountains for fully fifteen miles, cuts through the foot hills and is lost amid the sands and gravels of Crow Flat valley. Several small tributaries encroach upon the mountains somewhat, but in general the drainage area is confined to the foot hills and the precipitous slope of the western mountain face. A very little timber, chiefly cedar, exists in this valley.

CROW FLAT VALLEY.

Crow Flat valley. which has been mentioned several times, is a remarkable valley which I am entirely unable to definitely explain. In order to understand it a much broader study than I was instructed to make will have to be made. extending both into New Mexico and far south of the Guadalupe mountains, and including the mountains on either side. That it is originally a valley of construction is plain, but in just what manner I cannot say. Its linear extension is in general north and south, extending, to my knowledge, fifty miles. The elevation near the point of the mountains is 4300 feet, thus being more than a thousand feet lower than a corresponding point on the east side of the mountains at an equal distance from the base. The valley rises toward the north and apparently heads in the gap between the Guadalupe and Sacramento mountains in New Mexico. I know nothing of the valley south of the Guadalupes, but am informed that it gradually loses elevation in that direction. The Guadalupe mountains form the eastern wall, and this is continued in a line of foothills with a precipitous western face far to the southward. These foothills lack elevation, in part by the absence of the white limestone which forms so much of the mountains proper. On the west side of the valley is a mesa having a high east-facing wall, with a gentle dip appearing to be eastward as viewed from the west side of the valley. Whether this trough is closed at the southern end or not I cannot say, although the uplift of the Davis mountains may have raised the southern portion.

PROBABLY LACUSTRINE.

The Crow Flat valley is filled with a great accumulation of very fine silt and sand. The borders are coarser and contain gravel and rounded pebbles, but from my limited examination I cannot pronounce these lake-shore deposits, for they differ in no apparent way from the delta deposits formed by the mountain gorges at present when they reach more level ground. Other evidences exist in favor of lacustrine origin, though I do not consider them conclusive. The deposits, from one side of the valley to the other, for a distance of from ten to fifteen miles, consists of a very fine silt, in the center at least forty-five feet deep. No channel exists to indicate fluviatile origin nor does it seem possible that a river could produce such a sediment over so broad an area. This is rendered still more doubtful when it is considered that there is a considerable, though gentle, rise on both sides toward the valley borders. Near and south of the point of the mountain the center of the valley is occupied by a series of shallow lagoons, in which water collects at times. The water is alkaline and gypsiferous, and crystals of selenite sparkle in the sand. One lake is a salt lake, supplied by a spring of brine, which, upon evaporation, produces a crust of salt—the source of supply of all the salt used by the ranchmen in a radius of a hundred miles or more. A stratum of alkaline water is found in this valley at shallow depths wherever sought after. Near the northern border of the alkaline lagoons is a bed of white gypsum, apparently interstratified with the clay deposits. This is exposed by recent erosion in a semicircle, and is apparently horizontal, or nearly so.

These various facts indicate a recent large lake, now in the last stages of desiccation; but, upon so incomplete a study, I hesitate to pronounce it one, but prefer to leave this to a later study by one who can give it a more extended examination than I was able to do; and this will serve merely as an indication of the possible existence of such a lake.

ORIGIN OF THE VALLEY.

The cause of this valley is also doubtful. It may possibly be a valley of erosion. Certainly much erosion has taken place on its borders, but no more than could be easily accounted for by lacustrine shore erosion. The southward slope is not counterbalanced by a barrier on the south, and might be considered evidence in favor of the erosion theory and fluviatile origin of sediment. Still, even this would not be conclusive, since the orographic movements to which this section has been subjected in late geologic time may have tilted the basin. A critical study will undoubtedly settle these points.

A simple explanation, though as yet without satisfactory proof, is that it is a valley of construction. Under a discussion of the stratigraphy this will be more carefully considered. On this theory a sup-

posed fault near the western base of the Guadalupe mountains has dragged up the west-lying strata, and produced a synclinal trough in the otherwise nearly horizontal strata.

SPRINGS SUPPLIED FROM THE MOUNTAINS.

From the above discussion it will be seen that the general dip of the strata in the Guadalupe mountains is a little north of east. Both the surface and underground water is guided eastward by this cause. The surface water flows away only in times of heavy rains, while the greater part of the water sinks into the rocks and passes away beneath ground. This appears upon the plateau at favorable places in the form of numerous large springs. Under the head of artesian water these springs will be described in connection with a discussion of the underground water supply.

STRATIGRAPHY OF THE GUADALUPE MOUNTAINS.

According to my observations Dr. Shumard's description is somewhat faulty in places. The dip of the strata is given by him as E. S. E., whereas I find that the dip is nearly east, and in places N. 70° E. The general succession of strata I find to be about as he has given. His section in descending order is as follows:

		Feet.
1.	Upper or white limestone	1000
2.	Dark colored or thinly laminated and foliated limestone	50–100
3.	Yellow quartzose sandstone	1200–1500
4.	Black, thin-bedded limestone	500

An approximate section at the point of the mountains where I understand his section to have been made is also in descending order, according to my observation, as follows:

		Feet.
1.	Upper or white limestone	1200–1500
2.	Dark colored limestone	50
3.	Yellow, clayey sandstone, with numerous bands of black and white limestone	1200
4.	Black limestone shale and slate	200

I saw no such development of black limestone as he mentions (4), though possibly he may have found other evidence elsewhere. Faulting and folding have duplicated the lower beds near the Point of the Mountain, and it may be that he overlooked these disturbances. The hurried nature of Dr. Shumard's journey and the difficulties attending geologic work at that time in the west would excuse an oversight of this nature.

As the dip is northeastward the beds are much higher at the Point of the Mountains than farther north. Above the massive limestone is another series of limestones and sandstones found only on the highest points in Texas, but, farther to the north, in New Mexico, these are

well developed and form the bulk of the mountains. I have made no section of these beds, but they cannot be less than 1000 feet in thickness.

Near the mouth of McKitterick canyon I made a detailed barometric section. The greater part of the sandstone beds (No. 3, previous section) are beneath this section which is in an ascending order.

		Feet.
1.	Thick bedded white limestone	30
2.	Fine grain massive thin bedded bluish grey limestone	15
3.	Massive thick bedded white limestone	20
4.	Shaly yellow limestone	1
5.	Thick bedded white limestone	6
6.	Yellow magnesian limestone	4
7.	Yellow magnesian limestone (shaly)	5
8.	Contorted greyish white limestone (*Fusilina*)	40
9.	White chalky limestone with ironstone concretions	10
10.	Yellow limy sandstone with ironstone concretions	8
11.	White limestone	12
12.	Yellow limy shale with much ironstone	30
13.	Thick bedded yellow magnesian limestone	30
14.	Yellow shaly magnesian limestone	50
15.	Thick bedded magnesian limestone	4
16.	Shaly magnesian limestone	2
17.	Thick bedded magnesian limestone	3
18.	Shaly magnesian limestone	31
19.	Massive blue limestone with flint nodules	10
20.	Hard flinty sandy limestones	2
21.	Massive dark blue limestone	5
22.	Slate and blue slaty limestone	28
23.	Fossiliferous (*Spiriferina*, *Bryozoa*, etc.), blue limestone with chert	5
24.	Similar limestone shaly with nodules and layers of chert	4
25.	White crystalline limestone fossiliferous in places sometimes thin bedded but generelly massive	26
26.	Dark blue slaty limestone	2
27.	Fossiliferous white granular thick bedded limestone	38
28.	Thick bedded grey blue limestone	4
29.	Similar magnesian limestone, shaly in places	21
30.	Shaly stinking limestone very fossiliferous	5
31.	White fossiliferous thick bedded limestone	25
32.	Shaly stinking dark blue very fossiliferous limestone	2
33.	Thick bedded white limestone (No. 1, previous section).	

It will be observed that the dark blue limestone spoken of by Dr. Shumard, and mentioned provisionally in the previous section, does not appear just below No. 33 in this section of detail, although numerous bands of dark blue limestone are found at various points beneath the white limestone. The total thickness of the above section is 478 feet. The upper 123 feet (No. 25 to 32 inclusive) belong, I believe, to to the white limestone series as exposed in the precipice at the Point of the Mountain. The next lower 54 feet (No. 19 to 24 inclusive) are

probably the equivalent of the dark blue limestone at the Point of the Mountain. The lower part of the section is the equivalent of the upper part of the lower sandstone series and indicates the gradation from one to the other. It is better developed at McKitterick canyon than at the Point of the Mountains The remaining sandstone series consists chiefly of yellow sandstone with many bands of limestone generally narrow and usually black or dark blue with a few layers of light colored limestone.

Still below this, is the series of black shales, dark blue limestones, and even slates, as far as the section is exposed at this point. Neither the true sandstone nor the underlying black shales appear in the mountains, except at the very point where they underly the precipice. Followed northward they quickly dip out of sight, but southward along the line of foothills the continuation of the mountains, both the sandstone and shales, appear. The total section exposed in the Guadalupes, approximately stated, cannot be less than 4000 feet, including the New Mexico series, which exist above the white limestone.

POSSIBLE CORRELATION WITH CENTRAL TEXAS CARBONIFEROUS.

No attempt will be made at a division of the strata on the insufficient data at hand, nor will any attempt be made to correlate these beds with the Carboniferous of the Central Texas Palæozoic region of which they are an undoubted westward extension. Such a correlation may never be possible, owing to the diverse condition of sedimentation under which they were laid down. This certainly cannot be done without a very careful comparative palæontologic study. Still I wish to point out a rather striking resemblance between the order of deposition of the two series. In Central Texas there was first a shallow water sandy deposit, followed by a deeper water limestone of quite uniform character, and thirdly, a shallow water sandy deposit—an exact repetition of what is observed in this series. The first includes the Richland and Milburn divisions, the second the Brownwood division, and the third the Waldrip and Coleman divisions. In the case of the Central Texas region we find both the top and the bottom of the series, but in the Guadalupe mountains neither end of the series is exposed in the studied section. Apparently the western series is the thinner of the two, although this cannot be asserted until more is seen of it; yet this is what we would expect, since all conditions of sedimentation in this region were apparently less favorable than to the eastward.

Compared with the Central Texas Carboniferous the lower series might be considered the Richland sandstone, the middle the Brown wood, and the upper the Coleman divisions, with the narrow Milburn or Waldrip divisions either merged into the other or wanting. This is simply a suggestion, which may sometime be of value. The absence

of any indication of the immediate proximity of a shore line is marked. The sandstone does not appear rippled nor cross-bedded, nor is there any conglomerate in the mountains, or even a coarse-grained sandstone. All the sandstones contain much clay and limy matter, and were apparently deposited in quiet water off shore. A carbonaceous shale has been found in both the upper and lower sandstone beds, but no indication of coal or coal plants are found elsewhere.

There was a gradual subsidence, followed, after a long interval, judging by the thickness of the limestone, by a corresponding emergence. It is doubtful if Permian beds were ever deposited upon these rocks, which may very probably have formed one border of the Permian sea.

AGE OF THE STRATA.

Dr. B. F. Shumard* has described fossils from these mountains, and pronounced them Permian. Without good evidence I would hesitate to pronounce an opinion contrary to his, especially with the limited knowledge at my command. But stratigraphic evidence is almost conclusively against his opinion. I travelled completely across the Central Texas Permian, and became familiar with the peculiar aspect of these rocks, and unhesitatingly state that there is no stratum in the Guadalupe mountains, which, upon lithologic grounds, could be mistaken for Permian. Lithologic grounds for correlation of age is, in general, bad; but in this case it is not so, for the red color of the Permian beds is so distinctive that its absence in neighboring beds is almost indisputable proof of a difference in age. The red beds are traced to within seventy-five miles of the Guadalupe mountains—a small distance in the consideration of a broad geologic question in a region of simple geology like this. Furthermore, the rocks are below the Permian. The Permian in Central Texas is found resting upon and probably grading into the upper Coal Measure rocks. It is a lacustrine deposit, with beds of salt, gypsum, conglomerate, red clays and limestone, generally unfossiliferous. Fossils are found in the Permian only in a few beds. On the other hand, the fauna of the Guadalupe beds is rich and varied, living in clear, open water. To be contemporaneous with the rocks now admitted to be Permian in Texas a barrier followed by deep sea would all have to exist in seventy-five miles between the westernmost Permian and the easternmost Carboniferous outcrop which I have seen. Such a condition is out of the question, and it seems to follow that the Guadalupe mountains form one end (the western) of a syncline, with the Central Texas Carboniferous for the eastern end and the Permian deposits resting in the trough.

The palæontologic evidence offered by Dr. Shumard shows a striking faunal resemblance to the Permian of Europe, and at that time he

*Trans. St. Louis Acad. Sci.; 1858, p. 387; 1859, p. 290.

was justified in his correlation, though I am certain that had the Central Texas Permian been known to exist he would have classed the rocks of the Guadalupe mountains as Upper Coal Measure, instead of Permian.

Dr. Shumard describes from these strata forty-four species of fossils, twenty-seven of which were new. Of these not one species has been recognized in the Permian of Central Texas.* In Miller's North American Geology and Palæontology four of these are given as Coal Measure fossils, three are referred doubtfully to the American Permian, and the remainder are referred to the Permian chiefly upon the authority of Dr. Shumard, though two or three of the species are recognized European Permian forms. I believe that a number of Dr. Shumard's species, from this locality, will be found identical with Upper Coal Measure fossils. There is certainly a striking resemblance between these fossils and the fauna of the Central Texas Coal Measures, and a marked difference from the species found in the Permian. Stratigraphic, palæontologic and lithologic features, therefore, all seem to prove that these rocks are Coal Measures, rather than Permian.

MONOCLINAL STRUCTURE.

The general stratigraphy of the mountains is simple, though complicated in places by small folds. No faults in the mountains have been detected. and a careful instrumental survey will be necessary to detect them. if any exist, for there is such a remarkable uniformity in character of many of the rocks, and a repetition of similar beds, that their discovery will be difficult.

Near the mouth of Dark canyon, in New Mexico, at the base of the mountains, the general dip is from 2° to 5° east, gradually increasing toward the mountains. The increase in dip is frequently quite sudden (25° in one case), followed by a more gentle dip, and thus the strata rise in a series of short monoclines, rarely more than one-fourth to one-half mile in length. Occasionally a very short, crumpled anticlinal fold is noticed, but the general structure is a large monocline, including the entire range, made up of numerous small monoclines. This is better shown in New Mexico among the alternating upper beds than in the Texas end, where the chief rock is the massive white limestone, in which small disturbances cannot be noticed.

In Dark canyon the greatest general dip that I saw was N. 75° E., 10° to 15°. In this section a great part of the mountains are little else than foot hills, but toward the Texas end the mountains become higher and here also the angle of dip increases. From the general dip of from 3° to 5° on the off-lying plateau, there is at the base of the mountains a rapid increase in angle

*See list by Dr. C. A. White, Am. Nat., Vol. XXIII, No. 266, Feb., 1889, p. 115.

towards the center of the mountains, where it reaches as much of 25° as a general dip toward the east. Small folds are present and noticeable in the less massive layers, which are sometimes quite crumpled. As the western border of the mountains is approached the an gle of dip becomes less—in some cases not more than 5° to 8°.

PROBABLE FAULT ALONG WEST FACE.

Passing over the mountains, on the west side, a sudden change in dip is noticed. The foot hills on this side have a general westerly dip averaging fully 10°, and often more. Small folds and faults are also abundant, and this character is noticeable for more than fifteen miles to beyond the Point of the mountains. The change in dip occurs in less than two miles, and is so sharp that it seems impossible to account for it by folding. Still, I am unable to prove a fault, owing to the lack of facilities and time at my command. It is true that the rocks on the west side resemble those upon the east side of the disturbance, in both cases being black shale, blue limestones and yellow sandstone; but this series of beds occurs at two places below the white limestone, and also above it. If the rocks dipping west are the equivalent of the uppermost series, then there has been a fault of fully 2000 feet throw, and the white limestone so strikingly shown in the precipice of the mountains is here beneath the Crow Flat valley. If the dark limestones are the equivalent of the series of beds just beneath the white limestone, there has been a throw of about five hundred feet. In the latter case the great thickness of white limestone has been removed by denudation, and the same is true if the disturbance is a simple anticlinal fold.

Tentatively I interpret this to be a great fault terminating the monocline of the Guadalupe mountains. I will not attempt to estimate the amount of throw, but the direction of the line of weakness is southeast and northwest, and is marked along its entire course by a valley bounded on one side by the precipitous Guadalupe mountains, on the other by the disturbed and faulted foothills, having an opposite dip west. The suddenness and sharpness of the change in dip, the disturbed character of the rocks which, on this theory, have been dragged up with the rising mountains, and the evident line of weakness, are my reasons for this conclusion, which is advanced tentatively. An instrumental section of the mountains is all that is necessary to determine this.

On the west side of Crow Flat valley, fifteen miles from the foot hills, the rocks appear to be dipping very gently eastward.

DELAWARE CREEK DISTURBANCE IN CRETACEOUS.

Shumard describes a disturbance in the strata of the Cretaceous*

*A Partial Report on the Geology of Western Texas. G. G. Shumard, 1886. Also Trans. Acad. Sci., St. Louis, 1858.

rocks near the mouth of Delaware creek, which is pre-Quaternary, as proved by the conglomerate of that age resting upon it. The rocks are tilted at various angles from 20° to 50°. I did not see the place he describes, but found a similar condition at two places southwest of the mouth of the Delaware. There seems to have been a line of disturbance in a N. E. and S. W. direction, for one of the places where the disturbed rocks were observed is south of the head of the Delaware and twenty-five miles S. E. of the place which Shumard describes. This line of disturbance is marked by the presence of a range of high hills for the entire distance. What connection this bears to the Guadalupe mountain uplift I am unable to determine, but the Carboniferous strata near the head of the Delaware, as well as the overlying Cretaceous, have a dip E. S. E. instead of N. E. by E., as is the case in the mountains. The trend of this line of disturbance is nearly parallel to the east face of the Guadalupe mountains, though at right angles to the supposed fault line above described and to the strike of the strata in the Guadalupe mountains. It may be that the plateau between the disturbance and the Guadalupe mountains is the upper end of a synclinal trough between the Guadalupe monocline and Delaware creek disturbance. The change in dip of the Carboniferous strata indicate this.

PRE-CRETACEOUS EROSION.

In a section from the eastern base of the mountains southeastward toward the head of the Delaware, the lower sandstones and dark, slaty limestones are exposed, but the thick-bedded massive white limestone does not appear, though to the east the lower portion is found just beneath the Cretaceous. Upon these lower beds rest the Cretaceous limestone. This points to a vast amount of erosion in pre-Cretaceous times, during which not only have 1200 to 1500 feet of massive limestone been removed, but also an upper series of beds of fully 1000 feet, and any Permian that may have existed. This enormous amount of erosion may all have taken place in post-Permian times, but it is quite likely that the Permian lake which existed east of this had near here its western shore.

The entire absence of the white limestone at the contact with the Cretaceous, not more than twenty miles from the Point of the mountains, where it exists in the form of a striking precipice, suggests that the precipitous ending of the mountain may be thus accounted for. There is a sudden jump, almost vertical, from high mountain to foot hills. The precipitous Point is fully 1500 feet above the top of the hills, which are a direct southward continuation of the line of disturbance and the difference in elevation, is approximately the thickness of the white limestone, which is not only absent on the hills south of the point, but is proved to have been removed at a point twenty miles southeast in pre-Cretaceous times. Quite likely, then,

the Point of the Mountain represents approximately the most southwestern extension of the white limestone at the time of the great uplift. It has undoubtedly fallen back some by erosion, but judging by the backward retreat of the rest of the eastern mountain face this retreat has not been very great. The backward erosion on.the eastern face has been small. as can be proved by the gentle dip of the rocks near the mountain base.

It thus seems probable that the southern and southeastern precipice at the Point is the result of pre-Cretaceous erosion, while the western precipice and its northward extension is possibly to be accounted for by a great fault. In both these cases the precipitous character is aided by the massiveness and uniformity of the rocks and the strongly developed N. E. and S. W. joint planes.

QUATERNARY ROCKS.

Quaternary rocks are present in many places on the plateau east of the Guadalupe mountains. The Quaternary deposits of Crow Flat valley west of the mountains have already been described. The Quaternary conglomerates which Dr. Shumard mentions* as several hundred feet in thickness are present as he describes them, and I will not repeat his description of them. The study of these deposits is a broad one, which cannot be made in a limited area, but must be connected with other similar deposits in widely different areas. The Quaternary deposits of Texas furnish a great study in themselves.

There is one point, however, that I am able to make. It is, that many of the so-called Quaternary deposits in this section are not Quaternary but recent. There is a class of conglomerate particularly well developed near the mountains, though extending, in some cases, far out upon the plains, which have neither been formed in lake nor sea, but are simply creek beds and mountain torrent deltas. I will not say that all the conglomerates are of this class, but there are many which are undoubtedly so. Every gradation may be seen between the present creek bed and the old creek beds now capping hill tops. It is furthermore an interesting fact, that most of the conglomerates, while often not exactly in the creek bed, are nevertheless in the stream valley, and the farther one goes from the stream the less frequent the conglomerate deposits become. Hill tops out of the stream valley are sometimes capped with conglomerate, even upon the plateau far from the mountains, but these may be old creek beds, as is certainly the case frequently nearer the mountains. The capacity for carrying large pebbles long distances that these mountain torrent streams and creeks possess is remarkable and the evidence of it is present at every hand. Still a general study of all the Quaternary deposits is necessary in order to unravel many obscure problems.

*Geology of West Texas, G. G. Shumard, 1886.

PART III.

ECONOMICS OF THE GUADALUPE MOUNTAINS.

ARTESIAN WATER.

The dip of the strata being to the east, all underground water has a tendency to flow in that direction. The effect of this tendency is shown in the presence of numerous large springs on the east side of the mountains and their almost complete absence on the west side. In general, these springs are pure water though invariably heavily charged with lime, the presence of which is shown by the tufaceous deposits about the springs. Often these beds are of considerable extent, showing that the deposits have been for a long time forming.

Frequently these springs come from the sandstone of the lower series, and in nearly all cases this is the direct source of supply, though the bed which supplies them is sometimes hidden by later formations. At the head of Delaware creek there are two springs within twenty feet of each other which posses widely different characters. One is so strongly sulphurous and saline as to be disagreeable to the taste, while the other is entirely free from such impurities. Shumard states that the former comes from the sandstones, the latter from the conglomerate. Such is not the case, however, for the surface rock from which they both escape is sandstone. At present a boulder of conglomerate, a remnant of the old stream bed, rests upon the sandstone near the fresh water spring. This conglomerate may have been more extensive at the time Shumard passed through the country, thus giving rise to his explanation of the phenomenon. Undoubtedly the supply of water for the two springs is in different layers of the sandstone.

The structure of a large part of the mountains is such as to form a good source of supply for artesian water. Beneath the white limestone is a great thickness of alternating soft sandstone, natural reservoirs, and hard black limestones, which form impermeable walls. The quite strong and uniform eastward dip furnishes a good head. There are two conditions, however, which are adverse to the extension of the water supply eastward. In the first place, Black river and Delaware creek form deep valleys of erosion, which have tapped some of the water-bearing strata. The other accident is the line of disturbance extending southwestward from the mouth of the Delaware. This has thrown all the rocks into a series of short folds, but the extent to which this has interfered with the artesian supply is at present unknown.

To make exact calculation with the present data is out of the question. In fact, it is doubtful if such calculations can be made under any circumstances without actual boring, since the region east and southeast of the Guadalupe mountains is one of great complication.

In the first place, the amount of pre-Cretaceous erosion will be difficult, if not impossible to determine, since the region is buried beneath the Cretaceous. In one place it is found that 1200 or more feet of white limestone has been removed, but how far this extends can hardly be told. Secondly, the amount of Permian beneath the Cretaceous, east of the mountains, if any exist, cannot be ascertained, since from the end of Permian times to the beginning of the Cretaceous, this country was apparently a land area subjected to denudation. Nor is the former Permian extension known. The thickness of the Cretaceous has never been measured in this section, though this is a much easier task. Still, even this is complicated by the probable irregularity of the pre-Cretaceous surface.

Thus it will be seen that an exact estimate of the probability of finding water at certain depths are out of the question. Captain Pope's unfortunate experience in searching for artesian water in this section, contrary to the advice of Dr. Shumard, seems to indicate an absence of artesian water. Still, he did not get down to the series of rocks which would be influenced by the Guadalupe mountains uplift. This much can be said, that in Texas, east of the Guadalupe mountains, there is very little chance of finding artesian water in the Carboniferous rocks without going to great depths, and even then the finding of water is a matter of uncertainty, owing to the disturbed condition of the rocks described above. Toward New Mexico, and northwest of the line of uplift noticed at the mouth of the Delaware, the chance of finding artesian water is much better, and I should expect in Southern New Mexico, west of the Pecos, and possibly also some distance east of it, to find artesian water at no great depth. In this place there is probably no Permian, the Cretaceous rocks are not very thick, but the amount of upper Carboniferous rock is a matter of uncertainty.

If water is found in the Carboniferous, it will in all probability be good, though the single spring at the head of the Delaware shows that there is some mineral water in these rocks. Water from the Permian is almost certain to be saline or gypsiferous, and water from the Cretaceous to be gypsiferous. The lower Cretaceous beds near and west of the Pecos are gypsum-bearing, some strata being a pure alabaster. The Trinity Sands seem to be absent here, though present but fifty miles east of the Pecos.

The lower Cretaceous beds in favorable place furnish artesian water, but I have not seen enough of the stratigraphy of these rocks to form any conclusion either upon the extent or source of supply of this water. At Pecos City is an abundant artesian supply of saline water from this source.

On the west side of the Guadalupe mountains there is little chance of finding artesian water. The Crow Flat valley is apparently a syncline, but the amount of country drained seems inadequate for

artesian supply. Yet without seeing the country west and north of this valley no final conclusions can be drawn. The lacustrine supply found in shallow wells, springs and lagoons is the accumulation of the surface drainage in the Quaternary deposits of clay and sand, and is not of deep-seated origin.

BUILDING STONES.

There is an abundant supply of limestone in these mountains for ordinary purpose of construction, but I saw no fine building stones—neither marble, sandstone, nor granite. An alabaster, probably of lower Cretaceous age, though possibly Jura-Trias, occurs at numerous points southeast of the head of the Delaware. It overlies the Carboniferous, but no fossils were found by which its age could be determined.

MINERALS.

Conditions seem to be unfavorable for the occurrence of mineral veins, though indications of a low-grade galena, copper and iron were found at several points.

COAL.

In the mountains proper there is no coal. The character of the rocks is such as to preclude the possibility of finding such deposits, being chiefly of off-shore origin. A carbonaceous shale, however, was found south of the point of the mountains in the lower dark limestone series, and again in a similar rock near the head of Delaware creek. I found no plant remains to indicate whether this was a marine or coal shale The general absence of coal plants in the series is strikingly noticeable, and is rather a proof against the possibility of coal even there. In the upper beds, however, conditions approach much more nearly those suited to the formation of coal, and here coal may be found; but as these rocks lie entirely within the territory of New Mexico it is not in our province to discuss them here.

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DEPARTMENT OF AGRICULTURE, INSURANCE, STATISTICS, AND HISTORY.

GEOLOGICAL SURVEY OF TEXAS.

E. T. DUMBLE, State Geologist.

BULLETIN No. 4.

A PRELIMINARY

ANNOTATED CHECK LIST

OF THE

CRETACEOUS INVERTEBRATE FOSSILS

OF

TEXAS,

ACCOMPANIED BY A SHORT DESCRIPTION OF THE LITHOLOGY AND STRATIGRAPHY OF THE SYSTEM.

BY

ROBERT T. HILL, F. G. S. A.,

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AUSTIN:

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AUSTIN:

STATE PRINTING OFFICE.

1889.

LETTER OF TRANSMITTAL.

Hon. L. L. Foster, Commissioner of Agriculture, Insurance, Statistics, and History, Austin Texas:

Dear Sir—The accompanying Bulletin No. 4, "A Preliminary Annotated Check List of the Cretaceous Invertebrate Fossils of Texas," was prepared at my request by Mr. Robert T. Hill, in order that the different field parties engaged in actively prosecuting the work of the survey might have at hand a concise statement of our present knowledge of this system, not only as an aid to the proper understanding and interpretation of its various horizons as they come upon them in their work, but in order that work already done may be fully verified or corrected without unnecessary duplication, and each be prepared to add such new discoveries as may be made from time to time.

I may add that in this bulletin is exemplified the typical co-operation of State and National surveys, i. e., the working out and preparation by the National survey of such purely scientific matters as is contained herein, which, while it is absolutely necessary to the proper prosecution of the work of the State survey in the discovery and description of the economic materials contained within the system, yet lacks that direct interest to the people of the State that obtains in the economics themselves.

Our thanks are therefore due to the Director of the United States Geological Survey for the assistance thus afforded us, as well as to Mr. Hill for his valuable services in its preparation.

Yours, respectfully,

E. T. DUMBLE,
State Geologist.

INTRODUCTION.

Mr. E. T. Dumble, State Geologist, Austin, Texas:

DEAR SIR—I herewith transmit the manuscript of a check list of the Invertebrate Fossils of the Cretaceous Series of Texas, which has been prepared by me without cost to the State. To ascertain and record the stratigraphic and faunal position of these fossils has long been an accompanying subject of the writer's investigations, but the fundamental questions of stratigraphy have precluded the publication of the paleontologic details, and the brief and still incomplete information contained in these pages would be even longer withheld were it not for the fact that the local studies of the formations can be advanced more rapidly with this information before the observer. The work is as condensed as is consistent with clearness. A brief statement is made of the present state of our knowledge of the Cretaceous formation of Texas. This is followed by a short description of the rocks of the standard section along the Colorado river, which transects these formations. The details of this section have been worked out with great care by Messrs. J. A. Taff and N. F. Drake under my direction, and will serve as a temporary standard by which to work out stratigraphic relations and prove invaluable in determining artesian well areas, in classifying the agricultural soils, building materials, and other economic features.

Following this is the Annotated Check List of known species and pseudo species, accompanied by catch references to name of author, place and year of publication, and stratigraphic occurrence of species, if known, together with notes. An attempt is made to show in tabulated form the range of these species, and to classify them into faunas. Finally the reference bibliography is added.

Nearly all the species herein mentioned were originally described without reference to their stratigraphic occurrences or faunal association, and this paper is an attempt to supply these omissions, as far as possible, and to make the paleontologic literature available to the student. The Check List, imperfect as it is, has been the result of many years observation and study. It was originally undertaken while the writer was a student in the laboratory of Cornell University in the year 1883, and has been amplified and remodeled from time to time as occasion afforded the opportunity. Although it contains, as far as it has been possible to ascertain, nearly all that is known at present upon the subjects treated, it is still incomplete in many details.

Acknowledgement should here be made to Mr. C. B Boyle, of the Divi-

sion of Invertebrate Paleontology of the United States Geological Survey, for his valuable aid in verifying references and preparing the list. Similar acknowledgement is also made to Mr. C. C. McCulloch, Jr., of your survey, for his valuable assistance in completing the manuscript and preparing it for the printer. His painstaking services and paleontologic ability have been invaluable.

A few pages of the check list have previously been published, at my own expense, as a bulletin of the School of Geology of the University of Texas, but as its completion was of immediate importance to the geological survey the pages already printed have been fully revised and included in the present work, and its publication from the University discontinued.

Very respectfully yours,

ROBERT T. HILL,

Assistant Geologist United States Geological Survey, in Co-operation with Texas State Geological Survey.

PRELIMINARY NOTES UPON THE CRETACEOUS SYSTEM OF THE TEXAS REGION.

The two series comprising the Cretaceous System occupy the areas of the State known as the Black Prairie, the Grand Prairie, and the two Cross Timbers, and unstudied areas in the eastern and trans-Pecos regions of the State.

To these strata the State owes a large part of her agricultural and general prosperity, for they are the foundation and source of the rich black waxy and other calcareous soils of the Black and Grand Prairie regions. In addition to their agricultural features, these formations are the most productive source of building material, while along the parting between them, extending the entire length of the State and dependent upon their stratigraphy, is a remarkable area of natural and artesian springs, as seen at Fort Worth, Austin, San Marcos, and elsewhere.

It is not the purpose of this paper, however, to enter into the economic discussion of these formations, but to give in brief language, for the benefit of the professional geologist, a resume of the scattered results which have been published from time to time concerning the strata under discussion, in order to aid in the field examination and to enable the geologist to ascertain exactly what is to be known and what is to be found out concerning them.

In beginning it should be distinctly understood that, notwithstanding the many scattered publications upon these formations, very little exact detail has been published concerning them, and that we are now just ready to begin their systematic study. and to publish results that will be of value both to the practical development of the country and to knowledge.

PRESENT STATE OF KNOWLEDGE OF THE TEXAS CRETACEOUS.

It is now known that the series of rocks which a few years ago were considered as the whole Cretaceous group of the United States east of the Rocky Mountains, or the section published by Meek and Hayden, rests in Texas unconformably upon another great series* of rocks of even greater thickness, to which I have given, out of deference to the town of Comanche where I first studied them, the name of the Comanche series; hence, we now have in the United States two great series, the Lower or Comanche and the Upper or Meek and Hayden series. Each of these is entirely distinct from the

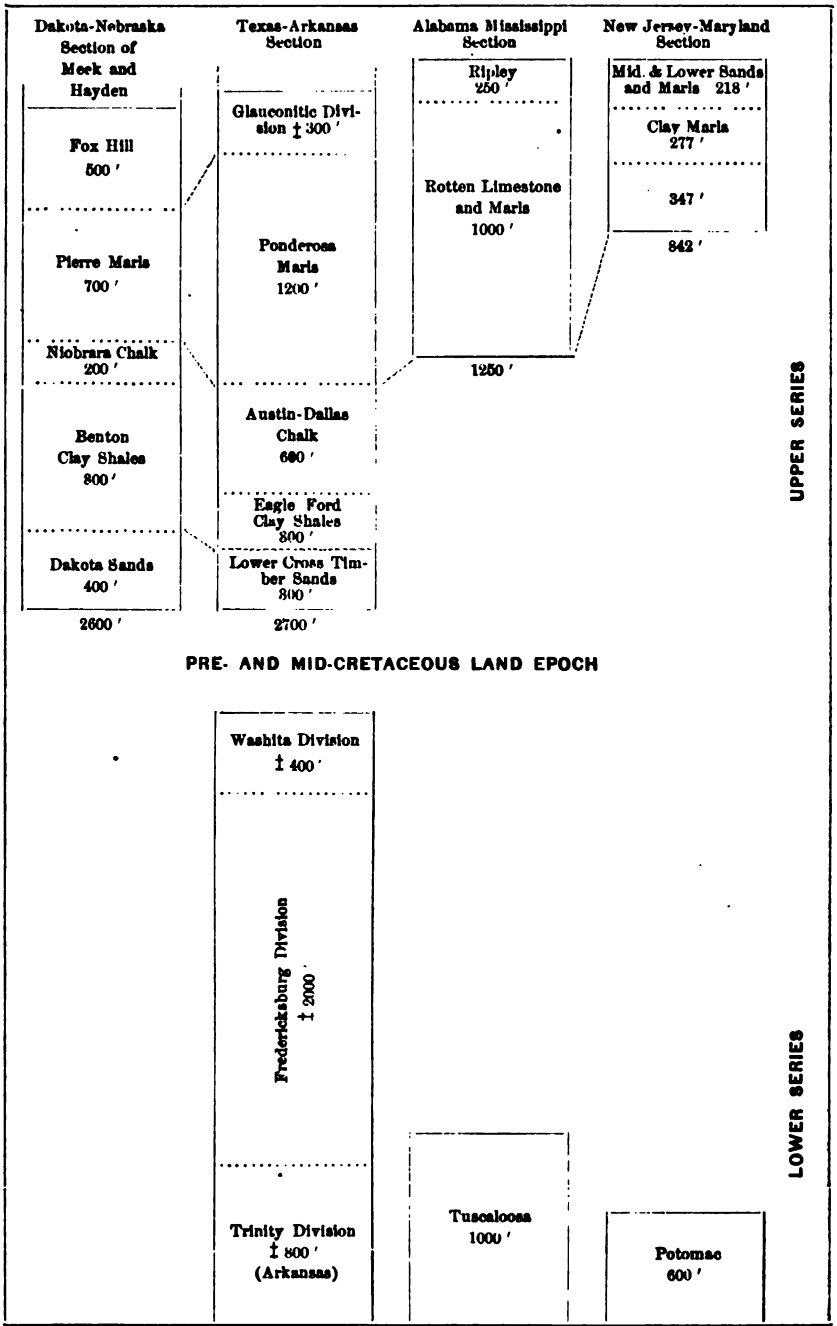
*The first announcement of this series was published by me in the American Journal of Science, January, 1887, p. 75. See Record of Science for 1886, Smithsonian Report, 1887-8, p. 220.

other, and each records a profound subsidence of the oceanic bottom and a subsequent elevation. Between them there was a land epoch, probably as long or longer than either of them.

This separate identity of the two series is shown by (1) the absolute stratigraphic break between them, as can be seen in numerous contacts in the city of Austin and elsewhere; (2) the radical change in character of sediments, as seen along the partings of the Lower Cross Timbers and the Comanche series; (3) the absolute change of life in the two formations, not a single species as far as known, passing from the Lower series into the Upper, thus indicating a lapse of time between them sufficiently long for an almost complete change of specific characters in the ocean's inhabitants.

The supposed relations of these formations to similar areas in the United States is set forth in the accompanying table:

Table showing Theoretical Relation of the Cretaceous System of Texas to other Cretaceous Rocks of the United States, east of the Sierras—1890.



Scale—1000 Feet to 1 Inch.

EXPLANATION OF THE NOMENCLATURE IN THIS PAPER.

In the present unstable condition of geologic nomenclature it is difficult to describe geologic facts in language that will convey the same meaning to all readers, and hence a few words are necessary concerning the terms used in this work. These are as follows: Group, System, Series, Division, Beds, and Horizon, as exemplified in the section on pages xiii and xiv. The term Group is used to indicate a series of formations produced in an interval coincident with a great geologic time, i. e., the rocks of Mesozoic time are called the Mesozoic group.

System is used to indicate the collection of rocks formed during a geologic period, e. g., the Cretaceous.

Series denotes the structural product of a single uninterrupted geological event corresponding to the writer's conception of a formation—a word which, owing to its ambiguity, however, is not here used. Each series of sedimentary rocks represents a more or less complete ternary succession of strata, i. e., the succession of deposits, first along shore, followed by deepening, and then by shallowing deposits to land again, as laid down by each subsidence and elevation of the ocean's bottom.

Division is used to express a broad subdivision of the conspicuous features of a series, usually founded upon some change in lithologic aspect, and not necessarily denoting minute differentiation or sharp line of demarkation. It may also be used to denote relative position in a series, as Upper, Middle, and Lower, without at all implying lack of continuity between them.

The term Beds denotes a well defined lithologic stratum or collection of strata within a series, possessing common characteristics, as the Exogyra Arietina clay. This term is equivalent to the word formation as employed by many geologists, and is only used tentatively until a more exact word is invented.

Horizon indicates the point of range of occurrence of a species (lithologic or paleontologic) within a stratum. Thus the horizon of *Terebratula Wacoensis*, Roemer, is at the top of the Washita limestone beds of the Washita division of the Comanche series of the Cretaceous system of the Mesozoic group.

It has not always been, but is fast becoming, a fundamental principle of geologic investigation that definition of strata should always precede their correlation, and hence local geographic names have been given to the strata described in this work wherever possible. Such nomenclature, however, during the reconnoissance stage of investigation may be imperfect, and subject to change.

The nomenclature used here for these subdivisions, though tentative and subject to change at any time, is considered the best that can be arranged at

present, and it is believed that into this classification can be placed all the rocks of the Cretaceous system as discovered.

There has been little attempt at revision of the genera or species of genera herein enumerated, all of which are in need of study, especially the Foraminifera, the Corals, and the Mollusca. Among the latter the Ammonitidæ, the Inocerami, the aberrant Chamidæ, and all of the Gasteropoda, are in special need of specific revision.

A BRIEF DESCRIPTION OF THE STRATIGRAPHY AND ROCKS OF THE CRETACEOUS SERIES OF TEXAS.

Based Principally upon a Preliminary Section along the Colorado River from near Smithwick Mills to Webberville.

It is essential that there should be a definition of the stratigraphic arrangement and composition and structure of the rocks composing the two Cretaceous series of Texas, as far as this is known, and in the following pages an attempt is made to fulfill this need. It is believed that, with a few exceptions, the general sequence of the principal features have been solved, but concerning the subdivisions and local variations very little has been recorded. The following descriptions are based upon the writer's personal study and upon an accurately measured section of the Comanche series, made under his direction, by Mr. J. A. Taff, of the State Geological Survey, the whole of which will be published later. No attempt has as yet been made to accurately measure the Upper series.

Progress Section Illustrating the Cretaceous System of Texas as Investigated to January 1, 1890.

II.

THE UPPER OR BLACK PRAIRIE SERIES.

DIVISIONS.	BEDS.	HORIZONS.	TYPICAL OCCURRENCE.
Glauconitic Division.			Mostly covered by tertiary overlap. Found in Anderson and Bowie counties, but best exposed north of Red River, in Arkansas.
Exogyra Ponderosa Marls, or Blue Bluffs Division.	Navarro - Webberville beds with arenaceous concretions.	Beginning of *E. costata*. E. Ponderosa, sub-costate var. Culmination of E. Ponderosa, Roem.	Main or eastern portion of the Black Waxy Prairie area of Texas, seen in Colorado section from Montopolis bridge to Webberville, especially at blue bluffs of Colorado. Walnut Creek, Travis Co.
Austin-Dallas Chalk, or "White rock."		Inoceramus.	In eastern portion of Austin, underlying all the chalky portion of city. Also at Waco, San Antonio, Dallas, McKinney, Sherman, and Rocky Comfort, Arkansas.
Eagle Ford Clays (Shales).	Upper calcareous clays. Lower blue clays, with giant nodules.	O. Bellaplicata, Shum.	Minor Black Prairie or Mountain Creek Prairie, lying between white rock scarp and Lower Cross Timbers.
Lower Cross Timber Sands.*			Coincident with extent of Lower Cross Timbers south of Grayson Co.

*Missing in Colorado section.

I.

THE LOWER OR COMANCHE SERIES (COLORADO SECTION).

DIVISIONS.	BEDS.		HORIZONS.	TYPICAL OCCURRENCE.
Upper or Washita Division.	Shoal Creek limestone (at Austin). (Impure.)		In north Texas replaced by Denison O. Quadriplicata beds.	Shoal Creek, Austin. S. bank of Colorado, at fish ponds.
	Exogyra arietina clays.		Final G. pitcheri, var. navia. E. arietina.	Shoal Creek at Twenty-fourth Street. Bluff near Barton Springs.
	Washita or Fort Worth limestone (chalky).		Terebratula Wacoensis. 3d Gryphæa beds. G. Washitaensis, with O. Carinata, O. Sinuata, Macraster elegans.	Fort Worth, Texas; railroad cut, W. Austin, Salado, etc.
	Upper Caprotina limestone.		Final Caprotina horizon.	S. base of Bonnel; McDonald's brickyard, Austin.
	Limestone Flags.			
Middle or Fredericksburg Division.	Caprina chalky limestone with flints. (Persistent.)		Rudistes, Monopleura, Caprotina, etc.	Summit of Jollyville and Jehosephat Plateaus, and bluffs of Deep Eddy, Austin.
	Comanche Peak chalk beds. (Persistent.)		Schloenbachia acute-carinatus, Comanche Peak Fauna, Ammonites pedernalis, Toxaster texanus. G. pitcheri beds with E. texana. Culmination bed of E. texana.	Comanche Peak, etc. Summit of Mount Barker, and many other localities. Bench of Mount Barker.
	Lower or alternately arenaceous, magnesian, calcareous division.	*Sub-Divisions.*		
		Upper beds of thin oolitic strata.	E. texana. (Gadolina Beds.)	Summit of Mount Bonnel above celestite beds. Bases of Mounts Barker and Bonnel, north of fault.
		Middle beds, with thick magnesian strata.	Celestite beds. Nerinea Austinensis. Tinoporus? chalk. (Gadolina Beds.)	Base of Bonnel ridge, near Bull Creek.
		Basal arenaceous beds, with thin strata.	1st Caprotina horizon.	Travis Peak P. O.
Lower or Trinity Division.	Upper or Packsand Beds. (Locally variable.) Basal or Contact Beds. (Locally variable.)			Sycamore Creek, Burnet County; Travis Peak P. O., Travis County.
Pre-Cretaceous.				

The two series of Cretaceous rocks in Texas are as distinct from each other in origin and occurrence as they are from the rocks of the overlying Tertiary and Quaternary systems, and hence it is necessary to describe them separately. They possess the following similarities, however: (1) Each is composed of sediments laid down upon a slowly subsiding and rising sea bottom, thus recording all the different ocean depths from littoral or shore condition to deep sea. (2) The general strike and dip of their rocks are in the same direction. (3) Each is characterized more or less throughout by an excess of lime—usually in the form of chalky calcium carbonate, pure, or mixed in every im-

aginable proportion with sand or clay. In every detail of these and other generic characters they are different.

The words limestone and chalk are used in these pages as follows: Limestone is employed generically for species of widely different origin and structure. Specifically they may be of five kinds. (1) Breccias composed of more or less comminuted and cemented shells of ancient ocean bottoms or shore. (2) Concretions or segregations formed by the segregation of the lime in clays and sands after original deposition—rare in our rocks. (3) Chalky rocks or those composed of amorphous calcium carbonate, usually more or less foraminiferal, void of lamination, and of comparatively deep sea (not abyssal) origin. These may be hardened by metamorphism into firm limestones; hence the term chalky limestone will imply chalky origin, and the term chalk present chalky condition. (4) Laminated impure limestones, occurring as alternating beds in sands and clays, indicative of shallower origin than chalk. (5) Metamorphosed limestones, or any of the above which have undergone induration or other secondary change.

All *laminated* limestones thus far found are more or less arenaceous or argillaceous, further proving their origin to have been in shallower waters than those in which chalk is laid down.

THE LOWER OR COMANCHE SERIES
(AS SEEN IN THE COLORADO SECTION.)

In general the Comanche series is predominantly calcareous, although, as will be shown later, there are a few exceptions. Its rocks from bottom to top record a complete Ternary succession of strata, to-wit: 1. A lower stage of sandstones, shales, and other sedimentary deposits, representing prevalence of land with downward movement. 2. A middle stage, chiefly of limestone, representing prevalence of sea and general quiescence and elaboration of calcareous organic formations. 3. An upper stage, and more of mechanical sediments, indicative of proximity to land.

The whole Comanche series is thus divided into three grand divisions, to-wit: The Trinity or Basal (sandy beds); the Fredericksburg or Medial (chiefly chalky beds), and the Washita or Upper division (impurer chalks and clays, alternating in stratification, becoming slightly arenaceous in the Denison region. but not so at Austin, for reasons explained later).

A.—THE TRINITY DIVISON.

This division is essentially arenaceous in composition, clastic in structure, and of littoral mechanical origin, being composed at its base of conglomerates or sands, the origin of every pebble of which can be located in the adjacent and more ancient strata of the Paleozoic region in the edges of Travis and Burnet counties, where the Trinity sands are in contact with the Paleozoic

rocks, schists, limestones, sandstones, and pre-Trinity granites. Succeeding the basal conglomerates are coarse, angular, cross-bedded sand, becoming finer and finer until it reaches the fine condition known in Texas as "pack sands," i. e., a fine grained sand which is cemented by included chemically precipitated calcium carbonate. Fossils have been found by the writer at Sycamore Creek, Burnet County, in the contact conglomerates, but they are neither plentiful nor distinct until the upper or pack sand beds are reached, one mile below Travis Peak postoffice, where the arenaceous layers are full of casts and moulds consisting of indeterminate Trigonias, Pholadomyas, Cyrenas, and an undescribed Ammonite resembling *Hoplites dispar.* In this vicinity, also, appears the first of the several conspicuous Grypheate beds of the Comanche series. This is composed of a solidified mass of large Grypheate oyster shells resembling the dilate species figured by Marcou as *Gryphæa dilata*, but not yet positively determined. These were found to form a breccia seven or eight feet in thickness, just below the crossing of the Travis Peak and Nameless road. Accompanying the *Gryphæa* breccia there is also the first appearance of another conspicuous feature in the Comanche series, i. e., an excess of magnesian sulphate. The oyster shells are being rapidly cemented into massive limestone beds or decomposing into a powdered earthy substance accompanied by incrustations of Epsom salts (Epsomite). This magnesian feature, which becomes more conspicuous higher in the series, is a fine illustration of an instance of the conversion of a shell limestone into dolomite by an alteration subsequent to the formation of the original rock, as has been recorded by Irish geologists.*

In places throughout the sands are occasional patches of red and greenish white clays resembling very much the characteristic features of the red beds of the lower formations. The cause of these discolorations has not been studied. There are about 300 feet of these arenaceous Trinity beds in the Colorado section, at the top of which appears a fossiliferous horizon—the first or lowest appearance of Monopleura and Requienia (Caprotina)—which we assume to be the beginning of the second division of the Comanche series. Thus the Trinity beds in the Colorado section are seen to be composed of locally derived debris, which, as the waters deepened, became more and more comminuted and calcareous until the sand grains at the top are almost imperceptible to the eye, and the whole mass becomes quite chalky and magnesian in appearance. As shown elsewhere, these basal arenaceous beds everywhere vary with the shore line upon which they were laid down, and are entirely different in the Brazos and Arkansas sections. (See Hill 1 and 4.)

B.—THE FREDERICKSBURG DIVISION.

The *Caprotina* horizon No. 1, which, according to our classification, lies at the

*See Prestwich's "Geology, Chemical, Physical, and Stratigraphical," Vol. 1, pp. 113, 114.

base of the Fredericksburg division, is apparently composed of equal parts of pack sand, calcareous matter, and magnesia in bands or strata of alternating degrees of consolidation, although showing a deeper and more uniform condition of sedimentation than the Trinity sands, yet, as shown by the alternating sediments, the deeper conditions of the Comanche Peak beds have not been reached. The alternation of harder and softer layers of arenaceous-calcareous strata now becomes prevalent, and the beds get thicker and more massive as the ocean's bottom descended. Such is the beginning of the Fredericksburg division, which may be divided into three lithologic subdivisions, to-wit:

(c) The Caprina Chalky Limestone Beds.
(b) The Comanche Peak Chalk Beds.
(a) The Basal or Alternating Beds.

THE BASAL BEDS.—The basal beds consist of white limestones of a coarse, crystalline, and chalky aspect, sometimes slightly brecciated, but seldom exceeding one or two feet in thickness and of great uniformity in extent of stratification. These beds are separated by softer unconsolidated, magnesian, arenaceous slightly argillaceous marls, resembling the yellow marls of France as I understand them to be.

This alternation of softer marls and harder limestones produces the beautiful bench and terrace topography of the western scarp of the Grand Prairie south of the Brazos and east of the coal measures. They seem to be missing, however, in the northwest. While more or less very finely arenaceous and calcareous at the base, the quantity of sand in the mixed strata gradually continues to decrease upward, and the chalky lime increases until the culmination of the chalky bed recorded in the next division. The yellow magnesian strata also increase in thickness and become very conspicuous in the middle portion of this lower subdivision after being from five to fifteen feet in thickness, as seen in the bluffs of Mount Bonnell north of the great fault. These magnesian limestones are soft enough to be cut with a knife, and are of an intense brownish yellow color. They alternate with similar strata of chalky limestones and yellow marls. The upper 100 feet of the basal subdivision of the Fredericksburg division, as seen at the top of Mount Bonnell, again present the unique stratification of the basal beds, the lime strata averaging about one foot in thickness.

The intervening yellow magnesian marls are soft and laminated, more or less siliceous, and composed of minute shells and concretions, which make it distinctly oolitic in character, and hence I propose for this stratigraphic horizon the name oolitic marls. These marls have very little clay, and pack when wet like fuller's earth. When properly understood they promise much, both from an economic and purely scientific standpoint.

They finally terminate in a persistent bed, which is especially distinguished by the abundance of the beautiful *Exogyra texana* Roemer (*O. flabellata*, type of Goldfuss), from which fact it is called the culminating horizon of *Exogyra texana*. From careful measurements of Mr. J. A. Taff, at Travis Peak, from the basal Caprotina horizon to the culminating horizon of *E. texana* inclusive, is a height of 406 feet. Throughout the series fossils are occasionally found, especially *E. texana*, *Nerinea*, *Requienia* (*Caprotina*), *Cyphosoma*, and casts or moulds of *Tylostoma prægrandis*, Roemer, *Arca*, *Trigonia*, and especially the peculiar globular foraminifera-like form, which has been called *Gadolina* by D'Orbigny. There are also horizons more or less chalky throughout, one of which is quite conspicuous in that it is composed of a small foraminifera, *Orbitolina* (*Tinoporus*) *texana*, Roem. The beds of magnesian limestone which mark the central third of this division are especially worthy of future study and observation from a petrographic and chemical standpoint. They are often accompanied by pockets of calcite, aragonite, celestite, and epsomite. This basal subdivision of the Fredericksburg division is not well known in the northwestern portion of the State, but apparently diminishes in importance in that direction, being only about 100 feet thick in Comanche county, but maintaining considerable thickness at Comanche Peak, Hood County, 100 miles eastward.

Comanche Peak Subdivision.—Immediately above the culminating *E. texana* beds the great series of deepening alternations terminates in a massive persistent chalky division, marking, no doubt, the beginning of the culmination of the subsidence of the sea bottom (as recorded in the succeeding Caprina chalk) which had been going on since the pre-Trinity land epoch. This subdivision is composed of white chalky limestone, which readily yields to disintegration, usually forming the sloping sides of buttes and mesas, and capped by the Caprina chalk, next to be described. It is especially characterized by its abundant fauna, consisting of the species given in the faunal lists at the end of this Check List. The especially characteristic species are *Toxaster texanus*, Roemer, and *Ammonites pedernalis*, Von Buch. At the base of the chalk there is usually another marked bed of Grypheate oysters (*G. pitcheri* with *E. texana*), as seen near the summit of Mount Barker, in the Bonnell ridge, and especially well shown in the town of Weatherford, extending on to Red River. This is the second, in ascending order, of the great Grypheate beds of the Comanche series, and is composed of countless numbers of individual shells of *Gryphæa*, and is of marvelous areal extent.

The chalky beds of the Comanche Peak subdivision are the most extensive and uniform of the Comanche series, and must ever stand as the basis for comparison, from which to estimate the relative value of the overlying and underlying horizons. It presents on weathering a sterile, rocky aspect,

and is covered by sparse, stunted, coriaceous vegetation. An interesting fact concerning this subdivision is that several hundred feet above it, its lithologic conditions are repeated and its faunal features reappear, but almost entirely modified as to species, only the *Neithea quadricostata*, Roemer, and *Gryphœa pitcheri* running into the Washita division, and these presenting broad varietal changes.

The Caprina Chalk and Chalky Limestone Subdivision.—Without any serious stratigraphic break in the chalky limestones the abundant Comanche Peak fauna disappears, and there continue 300 feet, more or less, of chalks and chalky limestones of varying degrees of consistency, from a pulverulent condition to firm limestones, which seem to be a secondary condition of the chalk produced by superficial hardening. These hard layers form the table rock of the buttes and mesas of the extensive Grand Prairie region, and are exposed in the river bluffs between Austin and Mount Bonnell, on the Colorado, where the chalk has been more or less hardened into firm limestones by the local metamorphism accompanying faulting. The lime kilns and quarries immediately west of Austin are all located on this subdivision.

Accompanying these chalks and chalky limestones are well defined layers of exquisite flint nodules, occupying apparently persistent horizons in localities. These flint nodules are oval and kidney shaped, ranging in size from that of a walnut to about two feet in diameter. Exteriorly they are chalky white, resembling in general character the flint nodules of the English chalk cliffs. Interiorly they are of various shades of color, from light opalescent to black, sometimes showing a banded structure. These flint nodules are beautifully displayed *in situ* in the Deep Eddy canyon of the Colorado, above Austin, where they can be seen occupying three distinct belts in the white chalky limestones.

Where these chalky limestones form the mesas of extensive plateaus, such as the remnants of the Grand Prairie west and southwest of Austin, the flints are left in great quantities as a residuum (the softer chalks being more readily decomposed into soils and washed away), and they cover large areas of country. They have also been transported eastward in past geologic times by marine and river action, and are distributed over large areas along the margin of the Black Prairie region as a part of the Post-Cretaceous gravels of that region. In some of these flints remarkable decomposition is exhibited, the product being geode-like cavities lined with quartz crystals and pulverulent products. In one instance an apparently unaltered specimen picked up *in situ*, upon being broken open revealed a small cavity filled with a liquid inclusion.

The fact that these are the only flint horizons, so far at least as is known to the writer, in the whole of the immense Cretaceous deposits of the United

States, is very interesting, and especially since they occur about the middle of the Lower Cretaceous series instead of at the top of the Upper series, as in England. It was from them that the Indians made their flint implements, and the ease of their lithologic identity will be of value to the anthropologist in tracing the extent of the intercourse and depredations of former Indian tribes inhabiting this region.

Occasionally the flints, especially an opalescent variety in Comanche county, possess nuclei in the shape of fossils, usually the *Requienia* (*Caprotina*).

The decomposition of these flints and of the adjacent limestones has produced some peculiar and unique effects in the rocks and landscape of the region, the silica replacing the calcium carbonate and leaving as a remnant a peculiar porous, cavernous rock, usually of a deep red color from the hydration of the iron pyrites into limonite, composed of the siliceous pseudomorphs of fossil *Rudistes*, *Hippurites* (rare), and other shells, the interstitial spaces glittering with minute quartz crystals which line them. This red rock is coextensive with the areal outcrop of the Caprina limestone.

Immediately west of Austin, along the downthrow of the great Bonnell fault in the bluffs of the Colorado, another peculiar transformation takes place in the Caprina limestone. Occasional red decomposing spots occur in the massive white chalky limestones. Upon closer examination the apparently non-fossiliferous limestone is seen to be undergoing decomposition into a dry pulverulent inflorescence, and as a residuum there remains a dry red dust and exquisitely preserved calcite pseudomorphs of many rare fossils, such as recently described by Roemer and White, the occurrence of which I have located in this horizon.

As this inflorescence takes place in all the limestones along the Bonnell fault, from the basal subdivision of the Fredericksburg to the top of the Shoal Creek limestone, the writer feels inclined to attribute it to the emanation of sulphur and other gases up the numerous joint and fault planes which they inevitably accompany. The thorough investigation of these important and peculiar phenomena may prove of great economic value, as traces of the following important economic products have already been discovered by a few tests: Potash, Salt, Strontianite, Anhydrite, Epsom Salts, Gypsum, and Gold, but in quantities as yet unknown. These inflorescences are coincident with the fault lines adjacent to the ancient volcanic disturbance of Pilot Knob.

The Caprina limestone is also productive of many rare building stones and other structural material, while the immense flint deposits will no doubt be ultimately utilized. The Caprina limestone was given its name by Dr. B. F. Shumard from the abundance of the peculiar aberrant fossils of the genus *Rudistes* (which have been described as *Requienia*, *Caprina*, *Monopleura*, *Ichthyosarcolithes*, etc.,) occurring in it. These peculiar forms abound, and are

found occasionally in great masses. Accompanying these beds are also many new and undescribed species.

The chalky deposit of the Caprina limestone is no doubt the continuation and culmination of the great Lower Cretaceous subsidence, and will be of great service in future interpretation and final correlation. It is very uniform, and covers large areas of the Grand Prairie plateau in southwest Texas, especially in the region adjacent to the lower Pecos. It also caps the mesas of the remnantal areas in the Abilene country, and as far east as Comanche Peak in Hood County. The railroad from Brueggerhoff to McNeil along the Williamson-Travis County line crosses a typical portion of its strike.

At Austin a fault of about 750 feet downthrow has broken this limestone division into two different areas, and hitherto confused its measurement.

C.—THE WASHITA DIVISION.

The Caprina chalky limestones which mark the culmination of subsidence in the Comanche series are succeeded by deposits of a lithologic and stratigraphic character which indicate that the ocean's bottom had reached the culmination of the long subsidence which it had been undergoing since the beginning of the Trinity beds, and had commenced the gradual elevation which finally terminated in the Mid-Cretaceous land. This shallowing is well illustrated in the rocks above the Caprina limestone, to which the name Washita Division has been given after the region where its rocks were first seen by early explorers near Fort Washita, I. T.

The Washita Division along the Colorado is composed of the following well marked subdivisions:

The Shoal Creek Limestone	+ 80
The Exogyra Arictina Clays	80
The Washita or Fort Worth Limestone	+ 150
The Caprotina Beds	+ 20
The Flagstones	+ 10
Total thickness in feet (estimated)	+ 340

Of these horizons only the Washita limestone and the *Exogyra arietina* clays are known to have any persistent extent, these being found as far north as the Arkansas-Choctaw line and southwest to the Pecos.

THE FLAGSTONES.—These can be seen at McDonald's brickyard, Johnson's quarry, Taylor's lime kiln, and other points immediately west of Austin. They consist of thin flagstones, of almost pure chalky limestone, varying from one to three inches in thickness, and are void of fossils.

The surfaces of the slabs, which are quarried for paving and building stone, are sometimes covered with the pentagonal markings usually attributed to mud cracks, and these are filled with soft yellow lime material. These

flags are only eight or ten feet in thickness, and their occurrence elsewhere than in the Colorado section has not yet been reported.

THE UPPER CAPROTINA LIMESTONE, OR AUSTIN MARBLE.—Immediately above the flagstones, along the line of the Bonnell fault, at nearly all the localities above mentioned, is a massive stratum of limestone often metamorphosed into marble, which is composed almost exclusively of the calcified shells of *Requienia* (*Caprotina*), *Nerinea*, etc., accompanied by occasional *Hippurites*. This horizon was confused by Dr. B. F. Shumard with the Caprotina horizon some 1000 feet below, which marks the beginning of the Fredericksburg division. Away from the metamorphism of the Bonnell fault and local igneous action, the bed has not the crystalline consistency of marble. This bed is interesting, inasmuch as it represents the final appearance of the more or less continuous *Requienia* fauna which outcrops at various places from the bottom to the top of the Fredericksburg division, and it is possible that this horizon may in reality represent the close of that division. Between the Caprotina limestone and the flagstone horizon there are beds of yellow laminated calcareous marls of a few feet in thickness, with the latest known horizon of *E. texana* and a peculiar *Panopæa*.

THE WASHITA OR FORT WORTH LIMESTONE.—Resting immediately upon the upper Caprotina limestone (whether conformably or not has not been determined) commences the Washita limestone—one of the most important beds of the Comanche series. This consists of a comparatively massive, chalky, sparsely fossiliferous limestone. The base and top are compact and the middle more disintegrated. It consists of impure chalky limestones, shell breccia, and calcareous marls in alternating strata, having the same general aspect upon weathering as the Comanche Peak beds. Lithologically it seems to represent a similar depth of deposition. Accompanying this return of conditions is an excessive abundance of life of great generic resemblance to the Comanche Peak fauna, but, with the exception of *Gryphæa pitcheri* and *Neithæa texana*, of entirely different species. In place of the small *Toxaster texanus* of the Comanche Peak, we have the large *Macraster elegans*, Shumard, Roemer; for the beautiful *E. texana* there is substituted the similar but larger *E. sinuata;* while the *Ammonites leonensis* has superseded *A. pedernalis*. Here, too, the *G. pitcheri* (type, var.) breccia, with *E. texana* has its duplicate in a breccia composed of *G. washitaensis* accompanied by *O. carinata*. In its upper beds, however, the Washita or Fort Worth limestone, especially in North Texas, begins to show shallower conditions. At Austin it terminates in a comparatively massive lime stratum with numerous individuals of the only *Brachiopod* species thus far discovered in the Lower Cretaceous series of Texas, to-wit, *Terebratula wacoensis*, Roem. The fossils in the Washita limestone show a tendency to persistent zones, as shown in the section, and

about the same species characterize each zone wherever the writer has observed them. These limstones are well exposed at Salado and Fort Worth, the latter city being situated directly upon them. They contain more clay in the latter vicinity, however.

THE EXOGYRA ARIETINA CLAYS.—In Shoal Creek, at Barton Springs, near Round Rock, and other places in the vicinity of Austin, the *Terebratula wacoensis* horizon of the Washita limestone is surmounted by about eighty feet of unctuous laminated clays of a greenish blue color previous to long exposure to the elements, and dirty yellow afterwards. The lower half of these clays is filled with the unique *E. Arietina* or ram's horn oyster, which occurs in no other known horizon in the world. There is no transition between these clays and the including limestone horizons, but the Washita fauna again appears somewhat modified in the upper portion. At Austin, in the contact of these clays with the Shoal Creek limestone, is found the last horizon of *Gryphœa pitcheri* Mort., which appears as the variety *navia*, but varying in shape and size, being characterized here chiefly by the thickness and size of its shell.

In the clays there are occasional segregations of the fossils into limestone, but these have no persistent extent or size.

There are also numerous crystals of selenite, which are a product of the reaction of the decomposing iron sulphides (pyrites) upon the numerous oyster shells.

These clay beds are worthy of closer study and definition than it has been possible to give them. Their purity, extent, and apparent freedom from littoral debris make them easily distinguishable. The Arietina clays produce a black waxy residual soil, the only truly black soil of the Comanche series, the others being chocolate black or other dull colors. The areal extent of these soils, however, is very limited.

THE SHOAL CREEK LIMESTONE.—In the western portion of the city of Austin, and for a few miles north and south, the uppermost strata of the Comanche series consist of beds of a peculiar limestone, which is especially well displayed in the rocky canyons of Shoal Creek, whence its name. This limestone is from forty to eighty feet thick, and of a dull yellow color, with many spots of red and pink.

It is stratified, and upon close examination it is seen to be made up of minute fragments of shell, which are rapidly losing their integrity by alteration either into a harder condition or by breaking down into a pulverulent powder, as in the case of the Caprina limestone before described. The red blotches have been attributed to several causes, to-wit: (1) The decomposition of iron pyrites; (2) the oxidation by heating of adjacent igneous material; and (3) the decomposition of contained volcanic ash and cinder which were deposited

contemporaneously with it. So far no iron pyrites have been found in the rock to sustain the first of these theories, while the second is untenable from the fact that it occurs remote from faulting contacts. The third theory, on the other hand, is made plausible by the occurrence of minute specks, which in thin slices of the rock, as seen under the microscope, appear to be decomposing olivine or other igneous matter breaking down into serpentine and iron oxides. This point has not been finally determined, however.

In places the Shoal Creek limestone is decomposing and crumbling, while everywhere it is much jointed and faulted. The fossils contained therein are interesting, but have been as yet but little studied. The top surface of this limestone has been corroded and waterworn, and deposited unconformably upon it can be seen the radically different sub-littoral unconsolidated clays of the basal Upper series.

THE DENISON BEDS.

This abrupt conclusion of the Lower Cretaceous, together with the Shoal Creek limestone at Austin, is local, and, as will be shown later, due to the peculiar igneous disturbances that prevailed in this vicinity. To the northward, where these disturbing conditions were not present, the final termination of the Comanche series is quite different, as seen at Denison, for instance, where the Washita limestone, as seen two and one-half miles north of the city, is succeeded by shallowing alternations of clays and impure limestones containing an abundant littoral fauna. The details of these beds have not been as yet accurately determined, but further field work will soon be undertaken in that region.

Dr. G. G. Shumard partially described these beds, as follows:

Marly Clay or Red River Group.[1]—Of these he says: "This member immediately underlies the fish bed of the arenaceous group (Lower Cross Timbers), and is described by Dr. G. G. Shumard as 'a blue marly clay, occasionally variegated with red and brown, and with thin bands of sandstone interstratified. The clay contains crystals of selenite, flattened nodules of compact brown and blue limestone, and septariæ of compact blue limestone, reticulated with brown, yellow, and purple spar. The nodules occur in the upper part and the septariæ towards the base of the formation. The best exposures of the group are in Grayson, on Post Oak, Choctaw, and Big Mineral creeks, where sections of from fifty to sixty feet have been measured. It occurs also on Red River, in Fannin and Lamar counties. The estimated thickness of the group in this part of the State is about one hundred and fifty feet; but we have not seen the base of the formation.'

[1] B. F. Shumard: "Observations upon the Cretaceous Strata of Texas." Trans., Acad. Science of St. Louis, Vol. I. 1856–60.

"Fossils are extremely abundant in the septariæ and nodules, and as far as I have been able to learn they belong to hitherto undescribed species. From the collections of Dr. G. G. Shumard I have been able to characterize the following: *Ammonites swallowi*, *A. inequiplicatus*, *A. meekianus*, *A. graysonensis*, *Ancyloceras annulatus*, *Scaphites vermiculus*, *Baculites gracilis*, *Cytherea lamarensis*, *Tapes hilgardi*, *Gervilia gregaria*, *Nucula haydeni*, *Panopæa subparallela*, *Corbula graysonensis*, *O. tuomeyi*, *Inoceramus capulus*, and *Inoceramus* sp. nov. Fossil wood is also common at several of the localities visited."

Dr. B. F. Shumard, however, almost inextricably mixed his brother's results in his generalized section of Texas rocks, and I am inclined to believe that some of these species belong to the Eagle Ford clays, and are so placed in the Check List.

THE STRATIGRAPHY OF THE COMANCHE SERIES IN GENERAL.

From the foregoing facts it is evident that the Comanche series possesses a well defined lithologic and stratigraphic history. Its lower division is essentially sandy, but becomes less and less so and more calcareous as the bottom upon which they were laid down subsided.

The alternating beds of the Basal subdivision of the Fredericksburg clearly show a deeper sea condition of origin than the Trinity, but not as deep as the chalk of the Comanche Peak and Caprina limestone subdivisions. After the latter there is a hiatus in our knowledge, but the Washita division reveals an elevation of the ocean's bottom as slow and positive as is the subsidence recorded in the other basal divisions. In brief, there is recorded[1] (1) a long continued subsidence, during which nearly one thousand feet of deepening sediments were laid down; (2) a long continued deep sea condition in which four or five hundred feet or more of chalks were deposited; (3) an elevation in which from three hundred to five hundred feet of shallowing sediments were deposited (the Washita division).

The lithology of the Comanche series is predominantly calcareous and is marked by several essentially chalky horizons.

There are also magnesian and arenaceous beds, but these are modified in color and appearance by the predominance of the accessory chalky matter. In color the tint is chalk white, yellow, cream-colored, and occasionally the white rock weathers into a dark grey, and not even in a single case are these rocks concretionary as recently recorded,[2] unless it is in a few feet of the Denison beds above mentioned.

[1] A recent writer has alleged concerning these rocks: "I have no doubt that the 4000 feet of limestone which I found in the San Carlos Mountains of Chihuahua were accumulated on a subsiding sea bottom. Deep sea forms seem to be either wanting or very rare. I did not detect any forms from top to bottom of the series that might not have lived in comparatively shallow waters." Am. Jour. Science, Jan., 1890, p. 70.)

[2] Am. Jour. Science, Dec., 1889, p. 443.

Portions of the section are stratified into bands of one foot or more, but a large majority of the strata are massive, while the whole series, except a few alternating marls and layers of the Trinity, are remarkably free from lamination.

THE UPPER OR BLACK PRAIRIE SERIES.

The writer believes the day will come when it will not be considered essential to discuss together the Comanche series and the Upper Cretaceous series, so different are they in every geologic aspect.

There can be but little doubt that the rocks now composing the Comanche series were elevated into dry land, that the succeeding land epoch continued as long as the time of deposition of either of the including series, and that the rocks of the Upper series were largely derived from the underlying Comanche strata, and laid down during an entirely different and later oceanic subsidence.

The Upper series has been well studied in the Northwestern States, by the late Prof. F. B. Meek, the geologist who has contributed the most that is known concerning the Cretaceous formations of that country. His descriptions are found in a volume entitled "A Report of the Invertebrate Cretaceous and Tertiary Fossils of the Upper Missouri Country." By F. B. Meek, Washington, 1876. The Upper Cretaceous series of Texas, while varying in many specific details from the section therein described, is so generically allied that it is evident those variations are merely local differences in the same great subsidence, and that nothing but long and arduous labor, to be yet performed, will reveal their exact affinities.

The Upper Cretaceous series of Texas is divided into five conspicuous lithologic divisions, each unmistakable in its stratigraphic and topographic individuality, yet gradating into its adjacent divisions. Not one of these divisions has been minutely or systematically studied, further than here presented, although work in this direction is now in progress.

THE LOWER CROSS TIMBER SANDS.

North of the Brazos to Red River the base of the Upper series is composed of a brown, more or less ferruginous, predominately sandy littoral deposit, resting unconformably upon various horizons of the semi-chalky beds of the Washita division. These sandy deposits present an infinite variety of conditions of cross-bedding, clay intercalations, lignitic patches, and variation in fineness of size and angularity of the uncemented particles, characteristic of typical littoral deposits, while occasionally there are found fossiliferous horizons. One of these on Timber Creek, near Lewisville in Denton County, occurred in association with lignite and cross-bedded sands, and was composed

of undetermined Cerithiidae, *Neritina*, *Ostrea*, *Aguillaria cumminsi* (White), and other littoral species. From a well at Whitesboro, which was dug in the sharp sands of this division, I procured fish teeth (*Otodus*), an Ammonite (*Scaphites*), and indeterminate mollusks.

In the vicinity of Red River these sands are covered by a Post-Tertiary sand, which confuses their identity there. South of the Brazos and at Austin these beds are entirely missing, a fact which is explicable in connection with certain volcanic events which took place just after they were laid down, exposing them to denudation before the next division was deposited.

No systematic study of these beds, as a whole, has yet been made, and the thickness is estimated from casual observations by the writer. There is no more inviting field in Texas for study than these beds. Dr. B. F. Shumard discovered dicotyledonous leaves in this formation, and reported the same in the proceedings of the St. Louis Academy of Science, vol. 2, p. 140. He also correlated these sands with the Dakota group, or No. 1 of Meek and Hayden's section. They are probably the same as the Arenaceous group of Shumard's Texas section.

THE EAGLE FORD SHALES.

Beneath the scarp of the white rock (Austin chalk) at Dallas, and extending westward through the "Mountain Creek country" to the Lower Cross Timbers, can be seen the clays of this division of the Upper series, the thickness of which I place at 400 feet as a low estimate. These clays in their medial portion are dark blue and shaly, highly laminated, and occasionally accompanied by gigantic "cannon ball" nodular septariæ. Their lower contact with the Cross Timber sands has not been seen by the writer, nor recorded to his knowledge. The uppermost beds gradually become more calcareous, gradating rather sharply into the chalk. At Austin these beds occur in the same relative position, but are of varying thickness, and at one place—where Tenth Street crosses Shoal Creek—they are missing, the chalk resting on the Shoal Creek limestone. The northwestern part of the city is underlaid by these clays, which are here more calcareous, and accompanied by thin bands of laminated limestone. South of the river, along the International Railroad, they are finely displayed in Bouldin's Creek, with the characteristic blue color on fresh exposure.

They also appear at San Antonio near the cement works there, and probably occur at many intermediate points. North of Waco they increase in extent and thickness, forming extensive black waxy areas in Hill, Johnson, and Dallas counties, west of the white rock scarp. I have proposed for these areas the name Minor Black Waxy Areas, to distinguish them from the main Black Prairie Area underlaid by the Ponderosa marls.

THE AUSTIN-DALLAS CHALK, OR WHITE ROCK.

Immediately succeeding the Eagle Ford clays comes the Austin-Dallas chalk, which is the most persistent, and at the same time the most representative division of the whole Cretaceous system. The general character of this division has recently been described to the writer as follows:

"The rock of this formation is a massive, nearly pure, white chalk, usually free from grit, and easily carved with a pocket knife. Under the microscope it exhibits a few calcite crystals, and particles of amorphous calcite, and innumerable foraminiferæ. The air-dried indurated surfaces are white, but the subterranean mass has a bluish white color. The rock weathers in large conchoidal flakes, with an earthy fracture.

"In composition it varies from 85 to 94 per cent of calcium carbonate, the residue consisting of magnesia, silica, and a small percentage of ferric oxide, as can be seen from the following analyses of unselected specimens by the chemist of the Survey.

	Texas.	Rocky Comfort.
Calcium carbonate	82.512	88.48
Silica and insoluble silicates	11.451	9.77
Ferric oxide alumina	3.648	1.25
Magnesia	1.189	trace.

"The thickness of this chalk at Rocky Comfort is over 500 feet, 100 feet of which can be seen at the surface, the remaining 400 feet having been penetrated by bored wells. So far as observed in Texas it averages the same thickness at Austin, Sherman, and Dallas. It is of great uniformity throughout its massive thickness and extent, but it shows a few local differences in hardness, which are sometimes due to surface induration.

"It so closely resembles some of the beds of the underlying Comanche and of the overlying Upper Cretaceous that until recently they have not been differentiated. Upon close examination, however, it is noticeable that the Lower Cretaceous beds, as seen where Little River crosses the Choctaw boundary, are distinctly stratified and very much harder and generally more or less crystallized from pressure, solution, and redeposition of the carbonate of lime in the chalk. The topography of the Rocky Comfort beds is also of a milder type than that of the Comanche series, and is recognizable even at a distance. Above all, it is distinguished by its softness and by its entirely different fossil remains. The Rocky Comfort beds are also distingushed from the other chalky beds of the Upper Cretaceous by their greater firmness, different fossils, and by their higher percentage of calcium carbonate. With the exception of the White Cliff chalk, the other beds of the Upper Cretaceous seldom contain more than fifty per cent of calcium carbonate, the average being

twenty to forty per cent. The Rocky Comfort beds are also the only ones of considerable extent which have these peculiarities, those at White Cliff being the only others known to bear even a partial resemblance to them. The western border of this chalk commences a few miles west of the southwest corner of the State of Arkansas, in Indian Territory, crossing Red River (the exposures continuing up the south side of the valley of that stream to the north of Sherman, where it deflects southward), passing near Whitesboro, Sherman, McKinney, Dallas, Hillsboro, Waco, Belton, Austin, San Antonio, and Spofford's Junction, Texas, beyond which it bends northward, appearing in the disturbed mountains in the vicinity of El Paso and the New Mexican realm, and again in No Man's Land, Kansas, Nebraska, and Colorado, where it is closely related and probably identical with the Niobrara chalk of Meek and Hayden.

"A great portion of the former extent of this chalk has been destroyed by erosion, and its western border in Central Texas is now receding eastward under the influence of excessive atmospheric decomposition and denudation. From Austin to San Antonio it is more stable, but west of the latter place erosion again becomes great. That the whole group once continued far to the west, and perhaps entirely across the State, is not at all improbable.

"The characteristic topographic and physical features of this formation as seen at Rocky Comfort, such as the gently undulating topography, the white crumbling exposures, the intense blackness of the soil, are so nearly identical with those of the same formation in Texas that they are indistinguishable."[1]

In the vicinity of Austin the soft and chalky structure is somewhat destroyed by the volcanic disturbances of the vicinity, such as the co-deposition of volcanic ash, and excessive jointing and faulting, but it maintains its pure chalky aspect elsewhere.

THE EXOGYRA PONDEROSA MARLS.

The Austin-Dallas chalk is succeeded by a remarkable deposit of clays, aggregating some twelve hundred feet in thickness, according to reported well borings and estimates of the normal dip. These clays occupy the whole of the main Black Prairie region east of the Austin-Dallas chalk, and form the basis of the rich black waxy soil. Notwithstanding their areal extent, good outcrops of the unaltered structure are seldom seen, owing to the quick decomposition into soil. However, at the Blue Bluffs of the Colorado, six miles east of Austin, a superb exposure is afforded, where these clays can be readily studied and diagnosed.

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[1] "The Neozoic Geology of Southwest Arkansas." Vol. 2 of the Annual Report of the State Geologist of Arkansas. Little Rock, 1888, pp. 90–95.

They are of a fine consistency, unconsolidated, and apparently unlaminated until exposed to weathering, when their laminated character is developed.

They are light blue before atmospheric exposure, but rapidly change into a dull yellow, owing to the oxidation of the contained pyrites of iron. Their chief accessory constituent is lime in a chalky condition, and they are more calcareous at their base than at the top. Near the top of these and other exposures there is to be seen a rapid transition into the black calcareous clay soil, characteristic of chalk and chalky clays, whenever their excess of lime comes in contact with vegetation.

The details of these clays have not been yet ascertained, and from the nature of the problem it is not evident that they can be discovered speedily, but the following facts are apparent: (1) That they are more calcareous and fossiliferous at their base, where they probably gradate into the Austin chalk. (2) That their middle portion is apparently void of well preserved fossils, yet impressions are abundant in places. (3) Toward the top, as seen one mile north of Webberville, ten miles east of Austin, they become slightly arenaceous and concretionary and very fossiliferous, indicating a gradation into the Glauconitic division.

The fauna of these concretionary clays at Webberville, Corsicana, and elsewhere begins to partake of the character of that of the Glauconitic division, and yields an abundance of species.

The Webberville beds are practically the uppermost exposure of the Upper series along the Colorado section, for they are overlaid at that point by the Lignitic or Basal division of the Eocene Tertiary. In East Texas, where the rivers have cut through these overlying Tertiary beds, and in Southwest Arkansas, which is but the northeastern termination of the Texas section, the Glauconitic or Arenaceous division is highly developed. This division is the upward continuation of the Ponderosa marls, its chief lithologic difference being that the clays gradate into sands and glauconite as we ascend, and there are conspicuous changes in the fossils, which become more plentiful, and the species assume a sub-littoral aspect, partaking of the same faunal characteristics that distinguish the Cretaceous of the New Jersey and Alabama regions. This division as it occurs in Southwest Arkansas has been minutely described in my Arkansas report, but its whole detail remains to be developed in Texas, its occurrence having only been affirmed in one or two places without specific detailed study[1].

GENERAL CONCLUSIONS ON THE UPPER CRETACEOUS SERIES.

The Upper Cretaceous series, including all the Cretaceous strata in Arkan-

[1]See Am. Journal Science and Arts, December, 1889.

sas from the base of the Rocky Comfort chalk upward, and in Texas from the base of the Lower Cross Timber sands, is continuous and unbroken, both stratigraphically and faunally. In structure it is, with few exceptions, unconsolidated, and in composition it varies from sands to clays, from clays to chalk, and from a pure foraminiferal chalk at its base through a thousand feet of chalky clays to arenaceous beds at its top, all of which indicates a complete Ternary succession of conditions, as in the Lower series, from land to deep sea and back to land again, the elevation taking a much longer time than the subsidence, as evidenced by the great thickness of the Ponderosa marls and Glauconitic division. The strata are apparently continous and unbroken in deposition and merge gradually one into another, and are connected from top to bottom by a unique, characteristic, and unmistakable fauna of marine mollusca.

In fact, both stratigraphic and lithologic evidence attest the unity of the sediments of this series of beds and their gradual change from sands through clays into pure chalks at the base, and from chalks to clays and sands at the top.

ANNOTATED CHECK LIST.

The first figure following the author's name refers to the full title of the original publication given in the bibliography at the end of the check list. The second figure gives the page of the original publication. The last figures are those of the year of publication. The capital letters refer to the formation and horizon. Species no longer considered valid, owing to previous description, are italicized. Comments are by the compiler. An * indicates that the species has not been figured. The localities are usually those given by the author of the species.

PROTOZOA.

Although the cretaceous rocks of Texas are mostly of foraminiferal origin, including innumerable microscopic species now being studied in the geological laboratory of the survey, none of them have been recorded except the following conspicuous microscopic forms:

NODOSARIA TEXANA, Con., 2, 159, 1857. W. Between El Paso and Frontera.
Occurs also in vicinity of Fort Worth, 700 miles east of original locality.

ORBITULITES (TINOPORUS) TEXANUS, Roem. 1, 392, 1849; 2, 86, 1852. F. Between New Braunfels and Fredricksburg.
This form composes the mass of a well defined chalk horizon south of the Brazos, as seen in the bluffs of the Colorado near the mouth of Bull Creek.

TEXTULARIA, sp. ind., Hill 3. A. Austin chalk.

GLOBIGERINA, sp. ind., Hill 3. A.

COELENTERATA. ANTHOZOA.

TROCHOCYATHUS (TURBINOLIA) TEXANUS, Con. 2, 144, 1857. W. Between El Paso and Frontera.

CLADOPHYLLIA FURCIFERA, Roem. 4, 1888. H. Barton Creek, [two miles] west of Austin.

ISASTREA DISCOIDEA, White. Geol. Mag. 1888, p. 662. N. "Navarro beds."
Have found what is probably this species in the shales at Eagle Ford.

COELOSMILIA AMERICANA, Roemer 4, 1888. H. Barton creek, west of Austin.

PARASMILIA AUSTINENSIS, Roemer 4, 1888. H. Barton creek, west of Austin.

PLEUROCORA COALESCENS, Roemer 4, 1888. H. Barton creek, west of Austin.

PLEUROCORA TEXANA, Roemer 4, 1888. H. Barton creek, west of Austin.

ASTROCOENIA GUADALUPAE, Roemer 1, 391, 1849; 2, 187, 1852. V.? Hills north of New Braunfels.

ECHINODERMATA.

OPHIODERMA, sp. nov., Hill 2, 1887. W. Fossil creek, six miles north of Fort Worth.

CIDARIS HEMIGRANOSUS, Shum. 2, 609, 1860. W. Bluffs of Red river, Lamar county, and ten miles above mouth of Kiamesha creek. Figured in White 2.

SALENIA MEXICANA, Schlut. 2, 1888. A.? Chihuahua, Mex.

HEMICIDARIS, sp. ind. An unstudied Hemicidaris, resembling *H. Crenularis*, Lam., is found in the Caprotina limestone west of Austin.

DIADEMA TEXANA, Roemer 1, 392, 1849; 2, 83, 1852; Fredericksburg, and San Saba river. F.

CYPHOSOMA TEXANA, Roemer 2, 82, 1852. F. Fredericksburg and San Saba river.

HOLECTYPUS PLANATUS, Roemer 1, 393, 1849; 2, 84, 1852. W. F. Fredericksburg and San Saba river.

PYRINA PARRYI, Hall, Con. 2, 144, 1857. W. Leon Springs.

CASSIDULUS AEQUOREUS, Shum. 1, 1858. A. Austin.

GALERITES (DISCOIDEA) sp. nov. Sierra Blanca district. A beautiful undescribed species collected by Prof. W. H. Streeruwitz, and now in the State collection.

HOLASTER COMANCHESI, Marcou 1, 1858. W.? Red river, near Denison.

HOLASTER SIMPLEX, Shum. 1, 84, 1854. W. Fort Washita, I. T.

TOXASTER TEXANA, Roemer 1, 393, 1849; 2, 85, 1862. F. Fredericksburg, Texas.

MACRASTER TEXANUS, Roemer 3, 181, 1888. W. Georgetown.

This conspicuous species is probably the same as the next. It is characteristic of and peculiar to tne uppermost horizon of the Washita division, and extends from Fort Washita, through Denison, Fort Worth, Salado, Georgetown, Austin, and southwestward.

HEMIASTER (MACRASTER?) ELEGANS, Shum. 1, 1854. W. Fort Washita, Indian Territory.

This form, owing to indefinite figure and description, can not be positively determined, but there are strong reasons for considering it identical with the foregoing.

Toxaster elegans, Con. 2, 146, 1857. W. Eagle Springs

HEMIASTER PARASTATUS, Shum. 1. A. Austin.

HEMIASTER TEXANUS, Roem. 1, 3, 1849; 2, 85, 1852. A. New Braunfels waterfall.

This common species is characteristic of the upper beds of the Austin chalk.

MOLLUSCOIDEA.

BRYOZOA.

ESCHARA, sp. ind. Hill 3, 1888. T. Millsap, Texas, and Murfreesborough, Ark.

ESCHARA, sp. ind.

An unstudied *Eschara;* is frequently met upon the moulds of fossils in the Comanche Peak beds.

Other Bryozoa have been frequently observed throughout the lower Cretaceous formation, but, as yet, there has been no systematic study of them.

BRACHIOPODA.

LINGULA, sp. ind. Shum. 2, p. 588.

TEREBRATULINA GUADALUPAE, Roem. 1, 408, 1840; 2, 182, 1852. E.P. Ford of Guadalupe, New Braunfels.

Also occurs at Austin and 200 miles north, in Dallas county. The original descriptions place the form in the genus Terebratula. Compare *T. Gracilis.* Sow.

Terebratula choctawensis, Shum. 1, 181, 1854. W. Near Fort Washita, I. T.

Terebratula leonenis, Con. 2, 164. W. Southwest Texas.

TEREBRATULA WACOENSIS, Roem. 2, 81, 1852. W. Waco Indian camp, west of New Braunfels.

This species occurs in great numbers in the uppermost layers of the Washita horizon, and I have traced its continuity from the Red river to the Rio Grande.

LAMELLIBRANCHIATA.

OSTREIDAE.

The Cretaceous Ostreidae of Texas belong to three widely distinct types, to-wit: (a) the normal form as seen in the living species, (b) forms having deflected beaks, as seen in the old but inseparable genera *Gryphaea* and *Exogyra*, and (c) the alectryonate varieties. Only the normal form is found in the shallow water horizons, while the others are nearly all found in deeper water sediments. Each species has a well defined horizon of occurrence, and a restricted vertical, but a wide geographical range, which facts, although hitherto little appreciated, make them of great value in stratigraphic determination.

a. Normal Forms.

Ostrea anomiaeformis, Roem. 1, 1849; 2, 1852. F.B. Ford and waterfall, New Braunfels.

I am inclined to believe this form a true *Anomia.* Common at Austin.

O. BELLA, Con. 2, 1857. Western Texas.

O. CONGESTA, Con.

This is a doubtful species, to which can be referred the young attached valves of nearly all adult forms.

O. CORTEX, Con. 2, 157. Dry Creek, Mexico.

This form occurs abundantly in beds which I conditionally refer to the Fredericksburg division. Found in the Trans-Pecos region.

O. FRANKLINI, Coquand. Hill 4, 1889. T.

Characteristic fossil of Trinity beds in Arkansas and Texas.

*O. LYONI, Shum. 3, 200, 1862. Pine Bluff, Red River county.

*O. OWENANA, Shum. 3, 200, 1862. N. Chatfield Point, Navarro county.

*O. PLANOVATA, Shum. 3, 201, 1862. N. Near Dresden, Navarro county.

Have not seen the three last mentioned species.

O. SUBSPATULATA, Lyell and Sowerby, Con. 2, 155, 1857. A? Western Texas.

O. VELLICATA, Con. 2, 156, 1857. Rio Grande, between El Paso and Frontera. W?

b. Gryphaeate and Exogyrate Forms.

**Gryphaea aucella*, Roem. 1, 395, 1849. F. Ford of Guadalupe, near New Braunfels.

It is strongly probable that all the oysters of this horizon belong to but one species.

G. CALCEOLA, Quenstedt var. *nebrascensis* M. & H., (4). F.

This species, distinguished from certain narrow forms of *G. Pitcheri* by its costate umbone, is occasionally found in the basal Comanche series.

G. forniculata, White 3, 293, 1879; 4, 13, 1880. Bexar county.

This is a variety of the naviate form of *G. Pitcheri* Morton, which according to Roemer and the type specimens, is the typical form of that species.

G. PITCHERI, Morton 1, 55, 1834. E.A., and V. Kiamesha Plains, I. T. 'The same variety was beautifully figured in Marcou 1, as *var. tucumcarri*.

This form, described long years before the stratigraphy of the southwest was studied has been the cause of endless confusion. Its history up to the present year has been given in Vol. II of the Arkansas Geological Survey for 1888. Notes in this check list embody still newer facts. I can now assert with positiveness that the form figured under this name by Morton, Roemer, Conrad and Marcou, and *G. forniculata*, by White, is a greatly variable but persistent species, occurring principally in the *upper* beds of the Washita division of the lower formation, and also in the Comanche Peak horizon of the Fredericksburg. The larger *G. dilatata*, Marcou, of Tucumcarri Mesa, and the entirely different dilated species occurring with *O. carinata* in the Washita limestone horizon, which I mistook for the foregoing before seeing Mr. Marcou's species, both in his collection and at Little Tucumcarri, and a diminutive new form in the Fredericksburg division which I once considered identical are persistent species and entirely distinct from *G. pitcheri* Morton. These conclusions are arrived at after years of study, not only of the literature and museum specimens, but personal visits to nearly every locality mentioned, besides hundreds of others throughout their extent.

G. pitcheri, Mort. *var. dilatata*, Hill 1, 100, 1888.

This is a persistent form occupying a well defined horizon in the Washita limestone, extending southward continuously through Denison, Fort Worth, and Austin. It is a new and distinct species. It is broader than long, and is especially marked by its small size, its fragile shell, and conspicuous, widely extended wing. I propose for it the name

G. WASHITAENSIS, sp. nov., as above.

This form will be illustrated at an early day.

G. PITCHERI, var. Navia, Hall 1, 100, 1856. False Washita, I. T., Camp 3.

As shown by Roemer, this is also the original form of Morton's poorly figured types, as seen in the Philadelphia Academy's collections.

G. PITCHERI var. *tucumcarri*, Marcou 1. See remarks on G. forniculata, White.

G. VESICULARIS, Lamarck. A., E.P., N.

This form is found only in the upper formation, and is especially abundant in the upper beds, associated with *O. larva* and *E. costata*. Owing to the fact that the uppermost or glauconitic beds in Texas are overlapped by the Tertiary, this species is not so abundant as in the east. It has been seen by me in Dallas and Travis counties, however, and thorough exploration of the intervening area will doubtless show its continuity. The form has been almost inextricably confused with G. *pitcheri* in early literature of the region, especially in the writings of Buckley and G. G. Shumard.

G. VESICULARIS, var. AUCELLA, Roem. 2, 74, 1852.

See *G. aucella*.

Exogyra aquilla, (Goldfuss) White, 6. W.

This is a young variety of G. *sinuata*.

E. ARIETINA, Roem. 1, 397, 1849; 2, 68, 1852. E.A. Mission Hill, near New Braunfels; San Marcos Springs, and Brazos river 30 miles above Torrey's trading house.

This unique form is confined to the clays of its name, which outcrop continuously across the State, immediately above the Washita limestone.

E. caprina, Con. 1*a*, 273, 1853. San Felipe creek, near Rio Grande, and in New Mexico.

This species is the same as the foregoing.

*E. COSTATA, Say, Roem. 1, 396, 1849; 2, 72, 1852. E.P?

Three miles east of New Braunfels.

This is another of the species characteristic of the upper horizons of the upper formation. See remarks on *E. fragosa*, *E. pondersoa*, and *G. vesicularis*.

E. FIMBRIATA, Con. 1, 54, 1857. Western Texas.

Doubtful species founded on one specimen.

E. FLABELLATA, Goldfuss, Marcou 1, 41, 1858. F. Cross Timbers and Fort Arbuckle, I. T.

This name is used for the species called *E. texana*, by Roemer, and *O. matheroniana*, d'Orb., by Conrad. It is the characteristic oyster of the Fredericksburg or lower division of the lower formation.

E. FRAGOSA, Con. 2, 155, 1857. Between El Paso and Frontera. W. V.

This species deserves a more complete description than could be given by Mr. Conrad with the data he possessed. It belongs with the large, exogyrate forms like *E. costata* Say, and *E. ponderosa* Roemer, being flatter and less globose than either of them, and possessing the rugose and costate markings in a less conspicuous degree. The form occurs in the uppermost layers (Shoal creek limestone) of the lower formation at Austin, and in the Franklin mountains and elsewhere in the Trans-Pecos region. It is the biologic and stratigraphic antecedent of the forms above mentioned, and unless one is thoroughly acquainted with their varietal limitations they are apt to be confounded.

E. læviuscula, Roem. 1, 398, 1849; 2, 70, 1852. A. Bed of Cibolo river, on New Braunfels and San Antonio road.

Common in Austin chalk from Arkansas to New Mexico, and in Utah. Young of *E. ponderosa.*

E. matheroniana, d'Orb. Con. 1, 154, 1857. F.? Between El Paso and Frontera.

Same as *E. flabellatta*, Goldfuss, Marcou, and *E. Texana*, Roemer.

E. PONDEROSA, Roem. 1, 395, 1849; 2, 71, 1852. A. E.P. East of New Braunfels, three miles.

The distinguishing fossil of the thousand or more feet of clay marls, between the Austin chalk and the glauconitic beds, and underlying the main black prairie region. It is the predecessor of *E. costata.* Its young in the Austin chalk of Texas, New Mexico, and Utah, has been described under many names.

G. SINUATA, var. AMERICANA, Marcou, 1, 37, 1858. W. Border of Red river, near Denison, Texas.

One of the most beautiful of the Texas oysters. It occurs in the upper part of the Washita limestone, throughout its narrow extent from Denison to Austin. It was redescribed under the name of *E. walkeri*, by White, in 1879.

E. texana, Roem. 1, 396, 1849; 2, 69, 1852. Fredericksburg.

See *E. flabellatta*, as above.

E. walkeri, White 2, 278, 1879. Salado, Bell county.

See *G. sinuata*, as above.

E. winchelli, White 3, 295, 1879. A.? Collin county.

c. Alectryonate Forms.

OSTREA BELLAPLICATA, Shum. 2, 608, 1860. F.B. Near Sherman, on the bluffs of Post Oak creek, and other localities in Grayson county.

Figured by White 2, 276, 1879. Occurs in upper part of Eagle Ford shales, from Grayson county southward.

O. blackii, White 3, 293, 1879; 4, 11, 1880. Collin county. Identical with foregoing.

O. CARINATA, Lam., Roemer 2, 75, 1852. W. Waco, Indian camp eight miles above New Braunfels.

A characteristic fossil of the Washita limestone, throughout its extent.

O. CRENULIMARGO, Roemer 2, 76, 1852. F.? Fredericksburg.

O. DILUVIANA, Lam., White. V. and W.

Occurrence rare at Austin, Salado, and elsewhere.

O. LARVA, Lam. G., E.P.

I have seen this characteristic Cretaceous oyster from the uppermost beds at Manor, Travis county, and elsewhere.

O. MARSHII, Sow., Marcou 1, 43, 1858. Pyramid mountain, N. M.

After a personal inspection of the formation in which this species occurs, I feel no hesitancy in pronouncing it entirely different and older than any

horizon in my Texas section. There is some reason to believe that it is the same as the *O. subovata*, Shum., which extends from the Travis Peak (Trinity) sands to the Shoal creek limestone.

O. QUADRIPLICATA, Shum. 2, 608, 1860. W. Bluffs of Red river, Lamar county, and ten miles above mouth of Kiamesha creek.

Found in decreasing numbers southward, at Fort Worth. This form attains four or five times the size of specimens hitherto figured.

O. SUBOVATA, Shum. 1, 179, 1854. W. Fort Washita, I. T.

A very poorly figured species. Also occurs as far south as Austin, in the Washita limestone. There are some reasons for believing this species identical with the lower-occurring form of *O. Marshii*, Marcou.

O. VELLICATA, Con. 2, 156, 1827. W. Rio Grande between El Paso and Frontera.

ANOMIIDAE.

The Anomiidae need revision. Species occur in the littoral beds of each formation in great abundance.

ANOMIA, sp. ind. Hill 4. A very small species occurring in great numbers throughout the Trinity beds in Arkansas and Texas.

A. ANOMIÆFORMIS, Roemer 1, 1849; 2, 1852.

See *O. anomiæformis*.

A. ARGENTARIA, Mort. Hill 4. E.P. Occurs in Arkansas abundantly.

ANOMIA *micronema ?* M. and H. An undescribed species, greatly resembling one of Meek's species from the northwest, occurs in the uppermost upper Cretaceous beds at Eagle Pass. It is specially marked by fine costae.

SPONDYLIDAE.

PLICATULA INCONGRUA, Con. 2, 153, 1857. A. Locality not given. d'Orb.?

P. PLACUNEA ? W. A species indistinguishable from the European forms, occurring abundantly in the Washita beds from Fort Worth to Denison.

SPONDYLUS GUADALUPAE, Roem. 1, 400, 1849; 2, 62, 1852. A. Waterfall of Guadalupe at New Braunfels; bed of Cibolo, at crossing of New Braunfels and San Antonio road. Compare *P. dumosum*, Morton 1, pp. 59–60, and *P. spinosum*, Sowerby.

Found also at Austin, Watters, and other places. One of the most characteristic species of the Austin chalk.

SPONDYLUS, sp. nov.? The writer has found in the Washita limestone, two miles northwest of Austin, a larger and different species from any hitherto noted in Texas, which will be figured at an early day.

LIMIDIDAE.

LIMA (RADULA) CRENULICOSTA, Roemer 1, 399, 1849; 2, 63, 1852. W.? Waterfall, New Braunfels.

L. KIMBALLI, Gabb 1, 1872, 26. F., W. Nugal. Mexico.

Greatly resembles and probably identical with following species.

L. wacoensis, Roemer 1, 399, 1849; 2, 63, 1852. W., E.A., and F. Waco camp, eight miles above New Braunfels.

L. leonensis, Con. 2, 151, 1857. W. Leon Springs.

Identical with preceding species.

PECTENIDAE.

*Pecten æquicostatus, Lam'k. Roemer 1, 398, 1849. Upper Brazos and Cibolo creek.

Not rementioned in Roemer 2, and hence the inference that the species was abandoned by him.

P. duplicosta, Roemer 1, 398, 1849; 2, 65, 1852. V.? North branch of of Pedernales.

I suspect that this species, which was confessedly described from a single imperfect specimen, is the same as the magnificent Pecten in the Shoal creek limestone at Austin, which I have referred to as *P. fleuriaussiana*, d'Orb., and as *Vola quinquecostata*, Sow. To avoid further confusion I have figured and redescribed this form under the name of *P. Roemeri.*

P. (Vola) Roemeri, Hill 5, 1889. V. Characteristic fossil of Shoal creek (Vola) limestone. Shoal creek, Austin.

Vola quinquecostata, Sow., Hill 3, 1889. See foregoing.

P. nillsoni, Goldfuss, Roemer 2, 67, 1852. A. Guadalupe river on New Braunfels-Seguin road.

Probably same as *Amusium simplicum*, Con.

P. quadricostatus, Sow., Roemer 1, 398, 1849; 2, 64, 1852. F.? and W. Waco camp, west of New Braunfels.

Associated with Washita limestone fauna throughout its extent.

Neithea occidentalis, Con. 1, 369, 1851; 2, 150, 1857.

Same as foregoing.

P. texanus, Roemer 2, 65, 1852. W. Water rolled specimens from debris of the Cibolo, at crossing of San Antonio and New Braunfels road.

A form of extreme variation of *P. quadricostatus*. Comparison of numerous specimens shows every gradation between them.

Amusium simplicum, Con.

Specimens which are provisionally referred to this species have been found by the writer at the top of the Ponderosa marls in Arkansas and east of Austin.

Camptonectes virgatus, Nils., Roem. 2, 66, 1852. A.? River drift of Guadalupe, below New Braunfels.

*Vola (Janira) wrightii, Shum. 2, 607, 1860. V. Found in the Caprina limestone, Shoal creek, Austin, and Barton creek, near Austin.

AVICULIDAE.

Avicula convexo-plana, Roem. 1, 400, 1849; 2, 61, 1852. F. Fredericksburg.

*Avicula irridescens, Shum. 3, 203, 1862. F.B. Head of Pine creek, Lamar county.

Avicula pedernalis, Roem. 1, 400, 1849; 2, 61, 1852. F. Fredericksburg.

Avicula planiuscula, Roem. 1, 401, 1849; 2, 62, 1852. F.B. Waterfall of the Guadalupe, at New Braunfels.

Avicula? stabilitatis, White 3, 296, 1879; 4, 15, 1880. F.B.? Collin county, Texas.

*Gervillia gregaria, Shum. 2, 606, 1860. D. and F.B. Bluffs of Red River, Lamar county. Probably same as next.

Aguillaria cumminsi, White 6. D. Timber creek, Denton county. Corresponds somewhat to *Gervillia gregaria*, Shumard. Types collected by me. R. T. H.

Gervillopsis ("Dalliaconcha") invaginata, White 6. F.B.? Fossil creek. W?

Inoceramus biformis, Shum. 2, 586, 1860. A. Austin.

* Inoceramus (*a*) capulus, Shum. 2, 606, 1860. F.B. Bluffs of Red River, Lamar county. Associated with *Ammonites swallovi*, Shum., and *Tapes hilgardi*, Shum.

Inoceramus confertim-annulatus, Roem. 1, 402, 1849; 2, 59, 1852. F.B. "Ford of Guadalupe, New Braunfels." Camp No. 4, Cross Timbers, Shum. 1, 180, 1854.

Inoceramus cripsii, Mant.? Roem. 1, 401, 1849; 2, 56, 1852. F.B.?, A.?, N. G. Con. 2, 152, 1857. Ford of Guadalupe, New Braunfels; bed of Cibolo, crossing of New Braunfels.

I have seen no specimens except from the Glauconitic division which could be satisfactorily referred to this species.

Inoceramus diverse-sulcatus, Roem. A. "Austin." Schlueter 1, 1888. Same as *I. diverse-digitatus*, Sow.

Inoceramus exogyroides, Meek. A. "Austin." Schlueter 1, 1888.

Inoceramus involutus, Sow., Schlueter 1, 1888. A. "Austin."

Inoceramus latus, Mant., Roem. 1, 401, 1849; 2, 60, 1852. A. F.B. Ford and waterfall, New Braunfels.

Inoceramus mytiloides, Mant., Roem. 1, 401, 1849; 2, 60, 1852. F.B. Ford and waterfall of Guadalupe at New Braunfels. Associated with *I. cripsii?*

Inoceramus mytilopsis, Con. 2, 152, 1857. A. "Southwest Texas."

Inoceramus problematicus? Schloth. F.B. Fish beds near Austin.

Inoceramus striatus, Mant., Roem. 1, 402, 1849; 2, 60, 1852. A. Waterfall, New Braunfels.

Inoceramus subquadratus, Schlueter 1, 1888. A. "Austin."

Inoceramus texanus, Con. 2, 152, 1857. G.? Western Texas and Jacun, three miles below Laredo, Texas.

Inoceramus umbonatus, Meek, Hill. A. Austin chalk.

(*a*) Note:—No revision of the Inoceraminae is here attempted. Thus far none of them are recorded from the Comanche series.

INOCERAMUS UNDULATO-PLICATUS. Roem. 1, 402, 1849; 2, 59, 1852. A. Waterfall of Guadalupe below New Braunfels.

AUCELLA?, sp. nov. H.

Several specimens of this genus from the Caprina limestone have recently been seen by the writer. Locality, west of Austin.

MYTILIDAE.

MYTILUS SEMIPLICATUS, Roem. 1, 402, 1849; 2, 55, 1852. A. Ravine between New Braunfels and Seguin, three miles below New Braunfels.

MYTILUS TENUITESTA, Roem. 1, 403, 1849; 2, 55, 1852. F.? Fredericksburg.

MODIOLA COCENTRICA-COSTELLATA, Roem. 1, 403, 1849; 2, 54, 1852. F. Fredericksburg and San Saba valley.

MODIOLA GRANULATO-CANCELLATA, Roem. 2, 54, 1852. A. Ravine between New Braunfels and Seguin.

MODIOLA PARVA, Hill 3. T. West of Weatherford, and at Murfreesboro, Ark.

MODIOLA PEDERNALIS, Roem. 1, 403, 1849; 2, 53, 1852. F. Fredericksburg and San Saba valley.

PINNIDAE.

*PIUNA LAQUEATA, Con. Whitf. 1, 1889. No locality given.

*PINNA, sp. ind., Roem. 1, 402, 1849. F. Fredericksburg.

P. quadrangularis, Goldf., tab. 127, fig. 8.

*PINNA, sp. ind., Roem. 2, 56, 1852. A. Chalk marls of ravine between New Braunfels and Seguin.

*PINNA, sp. ind., Hill.

I have seen two indeterminate species of Pinna—one in the Washita limestone at Fort Worth, the other in the Shoal creek limestone at Austin.

ARCIDAE.

ARCA GRATIOTA, Hill 3. T. Gypsum Bluff, Ark.

ARCA PARVA-MISSOURIENSIS, Hill 3. T. Gypsum Bluff, Ark.

*ARCA PROUTIANA, Shum. 2, 601, 1860. F. Comanche Peak, and Parker county, near Brazos river.

ARCA SUBELONGATA, Con. 2, 148, 1857. W.? Between El Paso and Frontera.

*ARCA, sp. ind., Roem. 1, 404, 1849. F. Fredericksburg and New Braunfels.

Probably same as *A. pholadiformis* d'Orb., l. c. III, pl. 315, figs. 1–5.

*CUCULLÆA MILLESTRIATA, Shum. 3, 202, 1862. T.? F.B.? Red river, Lamar county, Texas.

CUCULLÆA TERMINALIS, Con. 1, 148, 1857. F. A very persistent form in the Fredericksburg division.

CUCULLÆA MAILLEANA? d'Orb., Roem. 1, 403, 1849; 2, 52, 1852. A. Waterfall of Guadalupe, New Braunfels.

NUCULIDAE.

*NUCULA BELLASTRIATA, Shum. 3, 202, 1862. F.B.? Red river bluffs, Fannin county.

NUCULA HAYDENI, Shum. 2, 602, 1860. F.B.? Red river, Fannin county.

NUCULA SERRIATA, Shum. 2, 603, 1860. F.B.? Bluffs of Red river, Lamar county.

NUCULA SLACKIANA, Gabb. Whitf. 1, 1889. No locality given.

TRIGONIIDAE.

*TRIGONIA ALIFORMIS, Goldf. (Gabb, not Park.), Roem. 1, 404, 1849. A. Ford of Guadalupe, New Braunfels.

TRIGONIA CRENULATA, Lam. Roem. 2, 51, 1852; Shum. 1, 180, 1854. F. Fredericksburg and Cross Timbers.

TRIGONA EMORYI, Con. 2, 148, 1857. W. Between El Paso and Frontera.

TRIGONIA TEXANA, Con. 2, 148, 1857. W.? Leon Springs, Texas.

TRIGONIA THORACICA, Mort., Roem., 2, 52, 1852. A. Ravine between New Braunfels and Seguin.

Probably same as *T. aliformis* above.

*TRIGONIA, sp. ind., Hill. N. North of Webberville.

ASTARTIDAE.

CARDITA? EMINULA, Con. 1, 150, 1857. F. Leon Springs, Texas.

It is very doubtful whether this imperfect specimen is a *Cardita*.

ASTARTE LINEOLATA, Roem. 1, 404, 1849; 2, 51, 1852. F.B.? Ford of Guadalupe, New Braunfels.

ASTARTE ("STEARNSIA") ROBBINSI, White 6, 1887. W.

I collected the type specimens of this species in company with Prof. Robbins from the top of the Washita limestone, six miles north of Fort Worth.

ASTARTE TEXANA, Con. 2, 152, 1857. F. Western Texas.

This species is poorly figured and described.

ASTARTE WASHITAENSIS, Shum. 1, 180, 1854. F.? Camp No. 4., Cross Timbers.

CRASSATELLIDAE.

*CRASSATELLA LINEATA, Shum. 3, 201, 1862. N. Near Corsicana, Navarro county.

*CRASSATELLA? PARVULA, Shum. 3, 202, 1862. N.? Red river, Fannin county.

CRASSATELLA SUBPLANA? Con., Hill. N. Numerous specimens from two miles north of Webberville are here provisionally referred to this species.

CHAMIDAE.

*DICERAS, sp. ind., Roem, 1, 404, 1849; 2, 53, 1852. H. Edge of plateau near New Braunfels.

Requienia (Caprotina) bicornis, Meek 1, 126, 1876. F. Fort Lancaster, Texas.

There is no reason for separating this from *R. texana*, Roem.

Requienia patagiata, White 5, 6, 1884. H. "Near Austin, Texas."

This and accompanying fauna comes from the Caprina limestone exposed in Barton creek and the bluffs of the Colorado west of Austin.

Requienia (Caprotina) texana, Roem. 2, 80, 1852; White 5, 7, 1884. F. C. and H. "Near Austin, Texas." C. Highlands between New Braunfels and Fredericksburg; Waco Camp, 8 miles above New Braunfels; Salado creek; Sabine creek.

Marcou, in 1, 42, 1858, reports this form at "Comet creek, on left bank of the False Washita, associated with *Gryphœa pitcheri.*" I have found two distinct horizons where this fossil occurs in great plentitude—one at the base of the Fredericksburg, the other above the Caprina. Closer study may differentiate the species.

Monopleura marcida, White 5, 8, 1884. H. "Near Austin, Texas."

Monopleura subtriquetra, Roem. 2, 81, 1852. H. Valley of San Saba and upper arm of Pedernales river.

Monopleura pingiuscula, White 5, 81, 1884. H. "Near Austin, Texas."

A comparison of abundant material shows this is very near if not identical with *M. subtriquitra*, Roem.

Monopleura texana, Roem. 2, 81, 1852. C. H. Waco Camp on Gaudalupe river, 8 miles above New Braunfels. Associated with *Caprina Gaudalupae* and *C. crassifibra.*

Caprina crassifibra, Roem. 1, 408, 1849; 2, 79, 1852. C. Waco Camp, upper arm Pedernales river; San Saba river.

Caprina guadalupae, Roem. 1, 408, 1849; 2, 79, 1852. H. Waco Camp, 8 miles above New Braunfels. Associated with *C. crassifibra.*

Caprina planata, Con. 1, 268, 1855; 2, 147, 1857. H.? Oak creek, near Pecos, Texas.

Caprina occidentalis, Con. 1, 268, 1855; 2, 147, 1857. H. C. Pecos river, near mouth. (A. Schott.)

Caprina texana, Roem 1, 409, 1849. H. C. ? Road from Fredericksburg to New Braunfels.

Plagioptychus ("rudistes") cordatus, Roem. 4, 1888. H. C. Barton creek, west of Austin.

Have not seen this species.

Ichthyosarcolithes anguis, Roem. 4, 1888. H. Barton creek, west of Austin.

RUDISTAE.

**Hippurites austinensis*, Roem. 1, 410, 1849. A. Austin. This is *Radiolites.* Generic name corrected in Roem. 2.

**Hippurites sabinae*, Roem. 1, 410, 1849. "Sabine creek, between Austin (?) and Fredericksburg ? A. *Radiolites.* Species abandoned in Roem. 2.

HIPPURITES TEXANUS, Roem. 1, 409, 1849; 2, 76, 1852. H. C. Ford of Gaudalupe River at New Braunfels. (Probably rolled.) Gabb. in 1, 263, 1872, reports from Nugal, Chihuahua, Mexico. They are rare and occur only in the Comanche series. I have found one perfect specimen (now in the museum of Cornell University) in the Caprina limestone. Fragments are frequently brought in.

RADIOLITES AUSTINENSIS, Roem. 2, 77, 1852. A. Austin. Characteristic of Austin chalk and Ponderosa marls. I have seen it also at Canon City, Col., in Arkansas, and in Mississippi. Probably closer study will show its identity with the Alabama species.

LUCINIDAE.

LUCINA ACUTE-LINEOLATA, Roem. 4, 1888. H. Barton Creek, west of Austin. A beautiful and abundant species.

LUCINA PARVILINEATA, Shum. 3, 204, 1862. N. Near Corsicana, Navarro county.

*LUCINA SUBLENTICULARIS, Shum. 2, 602, 1860. F.B. Bluffs of Red river, in Lamar and Fannin counties. Associated with *Ammonites swallovi*, Shum.; *Inoceramus capulus*, Shum.; and *Gervillia gregaria*, Shum.

FIMBRIA STRIATO-COSTATA? d'Orb. III, p. 114, pl. 281, fig. 2; Roem. 1, 407, 1849; 2, 47, 1852. F. Fredericksburg.

CARDIIDAE.

CARDIUM CHOCTAWENSE, Shum. 2, 599, 1860. F.B. Post Oak creek, Grayson county. Associated with *Ostria bellaragosa* fig. in White 2.

CARDIUM CONGESTUM, Con. 2, 149, 1857. N.? Rio San Pedro. Valley of Royo San Felipe, Texas.

CARDIUM MEDIALE, Con. 2, 149, 1857. F. The cast of this species is very common.

Cardium transversale, Roem. 1, 406, 1849. F.? Fredericksburg. Specific name retracted in Roem. 2, 50, 1852.

PAPYRIDEA? (CARDIUM) SANCTISABAE, Meek., Roem. 1, 405, 1849; 2, 48, 1852. F.? Fredericksburg. V.? Spanish Fort (Northern Mississippi).

LIOCARDIUM (PACHYCARDIUM) SPILLMANI, Con. N. G. This characteristic upper cretaceous fossil is quite common at Corsicana and other points in Navarro county.

*PROTOCARDIA (CARDIUM) BRAZOENSE, Shum 2, 600, 1860. F. Johnson county, at Comanche Peak, a few feet above level of Brazos river, and near Patrick's creek, Parker county.

*PROTOCARDIA (CARDIUM) COLORADOENSE, Shum. 2, 599, 1860. F. Burnet, Travis, Bosque, Johnson, and McLennan counties, and according to G. G. Shumard several hundred miles further westward.

PROTOCARDIA (CARDIUM) FILOSUM, Con. 2, 150, 1857. F.? Leon Springs, Texas.

PROTOCARDIA (CARDIUM) HILLANUM, Sow., Roem. 1, 406, 1849; 2, 49, 1852. F., W. Fredericksburg and San Saba valley. Most of the species above mentioned probably belong to this form.

PROTOCARDIA (CARDIUM) MULTISTRIATUM, Con. 2, 149, 1857; Shum. 1, 181, 1854. F. Leon Springs, Texas. Camp No. 4, Cross Timbers.

Protocardia (*cardium*) *texanum*, Con. 2, 150, 1857. W. Between El Paso and Frontera, Texas. Same as *P. hillanum*, Sow., above.

CYRENIDAE.

CYRENA ARKANSAENSIS, Hill 3. T. Gypsum Bluff, Ark.

CYRENA, sp. nov. H. Barton's Creek west of Austin. Undescribed species in State collection.

CORBICULA PIKENSIS, Hill 3. T. Gypsum Bluff, Ark.

CYPRINIDAE.

CYPRINA ? sp. ind. Roem. 1, 407, 1849; 2, 47, 1852. F. Upper branch of Pedernales river.

VENILIA (VENIELLA) CONRADI, Mort. Whitf. 1, 1889. No locality given.

*VENILIA (CYPRINA) LAPHAMI, Shum. 3, 204, 1862. F.B. ? Bluffs of Red river, Fannin county.

ISOCARDIA WASHITA, Marcou 1, 37, 1858. F.B. On banks of Red river, near Denison. I have found this species in Eagle Ford clays, four miles south of Denison.

ISOCARDIA, sp. ind., Roem. 1, 405, 1849; 2, 50, 1852. F. Fredericksburg.

VENERIDAE.

TAPES HILGARDI, Shum. 2, 601, 1860; White 4, 22, 1880. F.B.? Bluffs of Red river, Lamar and Fannin counties.

*VENUS SUBLAMELLOSUS, Shum. 2, 598, 1860. F.B. ? Five miles north of Sherman, Grayson county. Associated with *Scaphites vermiculus.*

*Venus ? sp. ind., Roem. 1, 407, 1849; 2, 47, 1852. F. Fredericksburg.

CYTHEREA (DIONE) LAMARENSIS, Shum. 2, 600, 1860; Fig. in White 2. F.B. ? Red river, Lamar county. Probably same as *C. owena*, Meek & Hayden.

CYTHEREA (DIONE) LEONENSIS, Con. 2, 153, 1857. W.? Leon Springs, El Paso road, Texas.

CYTHEREA (DIONE) TEXANA, Con. 2, 153, 1857. W. Between El Paso and Frontera, Texas.

CYPRIMERIA CRASSA, Meek 1, 128, 1876. F.B. Pope's well, near Galisteo. I have found this species in Eagle Ford shales at Denison, Texas. Often confused with *Arcopagia texana* Roemer by collectors.

TELLINIDAE.

LINEARIA (ARCOPAGIA) TEXANA, Roem. 2, 46, 1852; Con. 2, 149, 1857. F. Fredericksburg. Leon Springs, Texas. Has been wrongly confused with *Cyprimeria crassa*, Meek.

LINEARIA ?. (SOLEN ?) IRRADIANS, Roem. 2, 45, 1852. F. Fredericksburg.

GARI (PSAMMOBIA) CANCELLATO-SCULPTA, Roem. 2, 46, 1852. A. Waterfall of Guadalupe river. New.Braunfels.

PAPHIIDAE.

TAGELUS (LEGUMEN) ELLIPTICUS, Con., Shum. 4, 1862. Navarro county.

SOLENIDAE.

*SOLEN ? ELEGANS, d'Orb, l. c. III, p. 322, pl. 351, figs. 3–5; Roem. 1, 407; 1849. F. Fredericksburg.

PHOLADOMYIDAE.

*PHOLADOMYA LINCECUMI, Shum. 3, 199, 1862. N. Corsicana, Navarro county.

PHOLADOMYA PEDERNALES, Roem. 2, 45, 1852. F. Fredericksburg.

PHOLADOMYA TEXANA, Con. 2, 152, 1857. F.? Turkey creek, Leon and Eagle Pass roads.

HOMOMYA ALTA, Roem. 2, 45, 1852. F.? V.? Fredericksburg.

*PANOPÆA[1]? NEWBERRYI, Shum. 2, 605, 1860. F. Parker county, and Comanche Peak, in Johnson county. Probably same as *P. recta* d'Orb. "Pal. France," tom. 5, p. 384, pl. 356, figs. 1–2.

Thracia ? myaeformis, White. F.? Same species as above. Genus indeterminate.

*PANOPAEA ? SUBPARALLELA, Shum. 2, 605, 1860. F.B. ? Red river, Fannin county.

*PANOPAEA ? SUBPLICATA, Shum. 3, 199, 1862. N. Chatfield Point, Navarro county.

PANOPAEA ? TEXANA, Shum. 1, 181, 1854. F. Camp No. 4, Cross Timbers.

*PANOPAEA ? REGULARIS ? d'Orb., l. c. pl. 360, figs. 1–2; Roem. 1, 407, 1849; 2, 45, 1852. V.? F.? Pedernales river.

PACHYMA ? AUSTINENSIS, Shum. 2, 604, 1860; White 2, 298, 1879. W. Shoal creek, near Austin. Associated with *Terebratula wacoensis, Turrilites brazoensis*, and *Ostrea subovata*. Salado, Bell county. (Walker.) Probably same as *P. gigas*, Sow., "Min. Conch," vol. 6, p. 1, pl. 504–505.

PACHYMA ? (CYPRICARDIA ?) TEXANA, Roem. 1, 404, 1849; 2, 50, 1852. F. Fredericksburg.

Pachyma ? compacta, White 3, 297, 1879; 4, 22, 1880. W. Bell county, Texas. Same as foregoing.

ANATINIDAE.

*ANATINA SULCATINA, Shum. 3, 204, 1862. N. Chatfield Point, Navarro county.

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[1] It is doubtful if any of the following species should be called Panopaea or Pachyma, but as it is here impossible to revise the generic nomenclature, the authors' names are retained for this group. See Meek, "Invertebrate Paleontology," pp. 248–249.

LIOPISTHA (CARDIUM ?) ELEGANTULUM, Roem. 1, 405, 1849; 2, 48, 1852. A. Waterfall of Guadalupe, New Braunfels.

MACTRIDAE.

MACTRA TEXANA, Con. 1, 269, 1855; 2, 148, 1857. G.? Prairie between Laredo and Rio Grande City.

MYIDAE.

*CORBULA GRAYSONENSIS, Shum. 2, 603, 1860. F.B. Post Oak creek, Grayson county. Associated with *Ostrea bellaplicata*, Shum., and *O. congesta*, Con.

*CORBULA TUOMEYI, Shum. 2, 604, 1860. F.B. Four and one-half miles north of Sherman, Grayson county. Probably same as *C. caudata*, Tuomey.

*CORBULA, sp. nov., Hill.
Seen in Caprina limestone from Gillespie county in collections of State Geological Survey of Texas.

*NEAERA ALAEFORMIS, Shum. 3, 203, 1862. F.B. Bluffs of Red river, Fannin county.

PHOLADIDAE.

TEREDO TIBIALIS, Con., Whitf. 1, 1889. No locality given.

*TEREDO, sp. ind. Roem. 1, 408, 1849; 2, 44, 1852. F.B. Ford of Guadalupe, near New Braunfels.

GASTROPODA.

PLEUROTOMORIIDAE.

*PLEUROTOMARIA AUSTINENSIS, Shum. 3, 198, 1862. W. Near Austin, Texas. A common characteristic species of the Washita limestone.

PHASIANELLINAE.

*PHASIANELLA PEROVATA, Shum. 2, 597, 1860. F. Comanche Peak, in Parker county, near Brazos river.
A common characteristic species of the Fredericksburg division.

*PHASIANELLA, sp. ind., Roem. 1, 414, 1849; 2, 38, 1852. A. Waterfall of Guadalupe, New Braunfels.

TROCHINAE.

TROCHUS TEXANUS, Roem. 4, 1888. H. Barton creek, west of Austin.

NERITIDAE.

NERITINA NEBRASCENSIS? Meek and Hayden, Hill 3. T. Between Granbury and Weatherford.

*NERITOPSIS BIANGULATUS, Shum. 2, 598, 1860. F.B.? Alexander's Bend of Red river, Grayson county.
Associated with *Inoceramus problematicus* and *Hamites fremonti*.

SOLARIIDAE.

SOLARIUM PLANORBIS, Roem. 4, 1888. H. Barton creek, west of Austin.

SCALARIDAE.

*SCALARIA (SCALA) BICARINIFERA, Shum. 3, 197, 1862. A.? Bluffs of Red river, Lamar county.

*SCALARIA (SCALA) FORSHEYI, Meek, Shum. 3, 195, 1862. N. Chatfield Pt., Navarro county.

*SCALARIA LAMARENSIS, Shum. 3, 197, 1862. F.B.? N.? Bluffs of Red river, Lamar county.

*SCALARIA, sp. ind., Hill. North of Webberville.

TURRITELLIDAE.

*TURRITELLA CORSICANA, Shum. 3, 196, 1862. N. Near Corsicana and Chatfield Pt., Navarro county; also Webberville, 10 miles east of Austin. This is very near *T. tippana*, Con.

*TURRITELLA IRRORATA, Con. 1, 268, 1855. W.? Between El Paso and Frontera. Probably same as *T. seriatim granulata* Roem.

TURRITELLA? LEONENSIS, Con. 2, pl. 21, fig. 7. F. W. E.A. A persistent species whose generic identity is still doubtful.

TURRITELLA MARNOCHI, White 2, 314, 1879. W. Vicinity of Helotes, Bexar county. See remarks on *T. irrorata*, Con.

TURRITELLA PLANILATERIS, Con. 2, 158, 1857. W. Associated with *Lima leonensis* and *Astarte crassifibra?* See remarks on *T. irrorata*, Con.

TURRITELLA SERIATIM-GRANULATA, Roem. 1, 413, 1849; 2, 39, 1852. F.? Fredericksburg.

*TURRITELLA WINCHELLI, Shum. 3, 196, 1862. N. Near Chatfield Point and Corsicana, Navarro county.

VERMETIDAE.

VERMETUS (SERPULA), sp. ind., Hill 3. T., etc. Gypsum Bluff, Arkansas. Indeterminate species found throughout the two Cretaceous formations of Texas.

NATICIDAE.

The reference of many of the casts of the Comanche series to the genus *Natica* is of doubtful value, and none of the forms so assigned are satisfactory. I have seen no true *Naticas* in the Lower Cretaceous, but they are beautifully preserved in the Eagle Ford shales and in the Navarro beds, the latter being of the type of *N. rectilabrum*, Con.

NATICA? (AMAUROPSIS?) AVELLANA, Roem. 4, 1888. H. Barton creek, west of Austin.

The generic determination of this calcite pseudomorph is very doubtful. Resembles the *Straparollus*-like *Solarium*.

NATICA COLLINA, Con. 2, 157, 1857. W.? Between San Pedro and Rio Pecos.

NATICA? TEXANA, Con. 2, 157, 1857. W.? Between Rio San Pedro and Pecos.

*LUNATIA? (NATICA) ACUTISPIRA, Shum. 2, 597, 1860. F. Parker county, near Brazos river.

TYLOSTOMA? (NATICA?) PEDERNALIS, Roem. 1, 410, 1849; 2, 43, 1852. F. Fredericksburg.

This common characteristic form of the Fredericksburg division is referred to the genus *Natica* with great doubt. It ranges from the Upper Jurassic into the Lower Cretaceous of Europe.

*TYLOSTOMA? (NATICA?) PRÆGRANDIS, Roem. 1, 410, 1849; 2, 44, 1852. F.? Fredericksburg, Pedernales river.

"This belongs near the form of the Portland chalk *N. gigas*, Bronn."—Roemer. Probably same as *N.? pedernalis*.

PALUDINIDAE.

VIVIPARA? CASSATOTENSIS. Hill, 3. T. Ultima Thule, Arkansas.

Mr. Jules Marcou has referred this species to *Natica*, but I think incorrectly. See "American Geologist," Dec., 1889, and Jan., 1890.

VIVIPARA (PLEUROCERA) STROMBIFORMIS, Schloth., Hill 3. T. West of Weatherford.

PYRAMIDELLIDAE.

Eulima? subfusiformis, Shum. 1, 182, 1854. F. A doubtful species.

EULIMA? TEXANA, Roem. 1, 413, 1849; 2, 40, 1852. A. Waterfall, New Braunfels.

CHEMNITZIA GLORIOSA, Roem. 1, 412, 1849; 2, 40, 1852. A. N. Waterfall, New Braunfels. Also occurs in Navarro beds.

CHEMNITZIA OCCIDENTALIS, Gabb 2, 186. F. W.? Choctaw Mission, I. T. Fredericksburg.

I have seen this beautiful species at Benbrook, Tarrant county.

CHEMNITZIA? (SCALARIA?) TEXANA, Roem. 2, 39, 1852. A. Waterfall of Guadalupe, New Braunfels.

NERINEIDAE.

NERINEA ACUS, Roem. 1, 412, 1849; 2, 42, 1852. F.? H. Fredericksburg. A characteristic species also of Barton creek or Caprina limestone.

NERINEA AUSTINENSIS, Roem. 4, 1888. H. Barton creek, west of Austin.

NERINEA CULTRISPIRA, Roem. 4, 1888. H. Barton creek, west of Austin.

NERINEA SCHOTTII, Con. 2, 158, 1857. H.? F.? Oak creek, near mouth of Pecos river. This species is beautifully preserved on the plains of the Pecos.

NERINEA SUBULA, Roem. 4, 1888. H. Barton creek, west of Austin.

NERINEA TEXANA, Roem. 2, 41, 1852. F. Fredericksburg. Pedernales river.

CERITHIIDAE.

CERITHIUM AUSTINENSIS, Roem. 4, 1888. H. Barton creek, west of Austin.

*CERITHIUM BOSQUENSE, Shum. 2, 596, 1860. F. Near Bosque river, Bosque county, Texas. Associated with *Exogyra texana* and *Lima wacoensis.*

CERITHIUM OBLITERATO-GRANOSUM, Roem. 4, 1888. H. Barton creek, west of Austin.

*CERITHIUM, sp. ind., Roem. 1, 414, 1849; 2, 38, 1852. A. Waterfall, New Braunfels.

APORRHAIDAE.

ANCHURA (DREPANOCHEILUS) MUDGEANA, White 2, 312, 1879. F.B.? Denison, Texas.

I have seen only one specimen—the type—in the National Museum at Washington.

STROMBIDAE.

*PUGNELLUS DENSATUS, Con. N. Corsicana, Texas.

ROSTELLARIA? COLLINA (cast), Con. 1, 157, 1857. F. Between Rio San Pedro and Rio Pecos. Associated with *Natica collina.*

ROSTELLARIA MONPLEUROPHILA, Roem. 4, 1888. H.? Barton creek, west of Austin. I am doubtful about this locality.

*ROSTELLARIA, sp. ind., Roem. 1, 414, 1849; 2, 38, 1852. A. Waterfall, New Braunfels.

FICULIDAE.

FICUS (PYRIFUSUS) GRANOSUS, Shum. 3, 196, 1862. N. Chatfield Point, Navarro county. Also at Webberville, 12 miles east of Austin.

FICUS SUBDENSATUS, Con., Shum. 4, 1862. Navarro county.

BUCCINIDAE.

BUCCINOPSIS ? CONRADI, Hill 3. T. Gypsum Bluff, Ark.

BUCCINOPSIS ? PARRYI, Con. 2, 157, 1857. F. ? Between Rio San Pedro and Rio Pecos.

PURPURIDAE.

PURPURA CANCELLARIA, Shum. 4, 1862. N. Navarro county, Texas.

RAPELLA SUPRAPLICATA, Con., Shum. 4, 1862. N. Navarro county.

FUSIDAE.

FUSUS ? (TURRIS ?) PEDERNALIS, Roem. 1, 414, 1849; 2, 38, 1852. H. Fredericksburg. This beautiful species occurs in the Caprina or Barton creek limestone.

*FASCIOLARIA, sp. ind., Hill. N. North of Webberville.

*PYRULA, sp. ind., Roem. 1, 415, 1849; 2, 137, 1852. A. Waterfall, New Braunfels.

VOLUTIDAE.

VOLUTILITHES NAVARROENSIS, Shum. 3, 192, 1862. Near Corsicana, Navarro county.

VOLUTA (ROSTELLITES ?) TEXANA, Con. 1, 268, 1855; 2, 158, 1857. G. Eagle Pass, Texas.

PLEUROTOMIDAE.

*PLEUROTOMA PEDERNALIS, Roem., Gabb 1, 264, 1872. F.? Nugal, Chihuahua. I fail to find where Roemer described this species.

*PLEUROTOMA TEXANA, Shum. 3, 197, 1862. N. Near Red River, Lamar county. Associated with *Cucullæa millestriata* and *Scalaria lamarensis*.

PLEUROTOMA TIPPANA, Con., Shum. 4, 1862. N. Navarro county.

ACTAEONIDAE.

*ACTAEON (TORNATELLA) TEXANA, Shum. 3, 194, 1862. F.B. Red River, Lamar county.

SOLIDULA RIDDELLI, Shum. 3, 194, 1862. N. Navarro county, Texas.

ACTAEONELLA (VOLVULINA) DOLIUM, Roem. 1, 411, 1849; 2, 43, 1852. F. Fredericksburg.

*CINULIA (RINGINELLA) ACUTISPIRA, Shum. 3, 193, 1862. F.B.? Red River, Lamar county.

*CINULIA (RINGINELLA) PULCHELLA, Shum. 3, 192, 1862. N. Chatfield Point, Navarro county.

*CINULIA (AVELLANA) SUBPELLUCIDA, Shum. 3, 193, 1862. N. Bluffs of Red River, Lamar county.

*CINULIA (AVELLANA) TEXANA, Shum. 2, 597, 1860. F. Near Bosque river, Bosque county. Associated with *Exogyra texana* and *Ammonites pedernalis*.

BULLIDAE.

GLOBICONCHA ? CONIFORMIS, Roem. 1, 411, 1849; 2, 42, 1852. F.? Fredericksburg, Pedernales river.

GLOBICONCHA ? ELEVATA, Shum. 1, 182, 1854. F.? Cross Timbers, Texas.

GLOBICONCHA ? PLANATA, Roem. 1, 411, 1849; 2, 42, 1852. H.? or W.? Waco Camp, eight miles above New Braunfels.

GLOBICONCHA ? (TYLOSTOMA ?) TUMIDA, Shum. 1, 182, 1854. F.? "Cross Timbers," Texas.

*GLOBICONCHA ? sp. nov. V. A very large undetermined species of *Globiconcha ?* Occurs in the Shoal creek or Vola limestone.

*CYLICHNA MINUSCULA, Shum. 3, 195, 1862. N.? Red river, Lamar county.

*CYLICHNA (BULLA) sp. ind. A. Occurs in Austin chalk at San Antonio.

*CYLICHNA SECALINA, Shum. 3, 195, 1862. N. Corsicana, Navarro county.

*CYLICHNA STRIATELLA, Shum. 3, 194, 1862.

SIPHONARIIDAE.

ANISOMYON HAYDENI, Shum. 3, 198, 1862. N. Chatfield Point, Navarro county.

*ANISOMYON, sp. ind. A. I have seen an undetermined species of *Anisomyon* in the Austin chalk from San Antonio.

CEPHALOPODA.

The *Cephalopoda* of the Texas region are greatly in need of biologic revision.

NAUTILOIDEA.

NAUTILUS DEKAYI ? Mort., Shum. A.? G. Specimens from the Austin chalk, mostly moulds, can be referred to this species. It also occurs in the glauconitic beds of Southwestern Arkansas, as well as in other regions of the United States Also, N. Shum. 4.

*NAUTILUS ELEGANS, Sow., Roem. 1, 418, 1849; 2, 37, 1852. W.? Waterfall, New Braunfels. The identity of this specimen is uncertain, but I am inclined to believe it the same species as *N. texanus*, Shum.

*NAUTILUS SIMPLEX, Sow., Roem. 1, 418, 1849; 2, 37, 1852. A. Waterfall, below New Braunfels.

*NAUTILUS TEXANUS, Shum. 2, 590, 1860. W. "Near Austin." Also bluffs of Red river, Grayson county. Associated with *Macraster? elegans* and *Ostrea subovata*. Compare *N. elegans* and *N. pseudo-elegans*, d'Orb.

*NAUTILUS, sp. nov., Hill. A well defined species from the Shoal creek limestone at Austin.

CRIOCERAS (ANCYLOCERAS ?) TEXANUS, Hill 4, 1889. Fort Washita, I. T. (Reported.)

This supposed new species, described by me from a specimen alleged to have been taken from the cretaceous rocks of Fort Washita, Indian Territory, is pronounced by Prof. Alpheus Hyatt, of Boston, to be *Lituites bickmoreanus*, Whitfield, a nautiloid species originally found in the Niagara limestone of Wabash, Indiana. As I have been informed by other paleontologists that they have seen the same species from the Washita limestone, it is with the gravest doubts that I withdraw it from the cretaceous fauna, in deference to Prof. Hyatt's opinion as the authority on the *Ammonoidea*.

AMMONOIDEA.

Ammonites acuto-carinatus, Shum. 1, 183, 1854. F. Cross Timbers, Texas. Same as *A. peruvianus*, Von Buch.

AMMONITES BELKNAPII, Marcou 1, 34, 1858. W. Near Denison, Texas. Resembles the outer whorls of *A. peruvianus*, Von Buch.

*AMMONITES BRAZOENSIS, Shum. 2, 594, 1860. W. Shoal creek, near Austin, and in Grayson and Fannin counties; also in McLennan county, and near Fort Washita, I. T.

"Attains a greater size than any species seen in the Cretaceous of Texas." Compare *A. leonensis*, Con.

AMMONITES DENTATO-CARINATUS, Roem. 1, 417, 1849; 2, 33, 1852. A. Waterfall of Guadalupe, New Braunfels. Occurs in upper part of Austin chalk, at Austin.

AMMONITES FLACCIDICOSTA, Roem. 2, 33, 1852. E. F. Waterfall of Guadalupe, New Braunfels.

Compare *A. geniculatus*, Con.

Ammonites geniculatus, Con. 2, 159, 1857. W. Bed of Rio San Pedro, and Leon Springs, Texas.

Same as above?

Ammonites gibbonianus, Lea, Marcou 1, 35, 1858. W. Elm Fork of Trinity, Fort Worth.

AMMONITES GRAYSONENSIS, Shum. 2, 593, 1860. F.B.? Fannin county, near Lowell's Bluff; also 4 miles north of Sherman, Grayson county. Associated at latter locality with *Scaphites vermiculus*. Fig. in White 2, species indefinite.

AMMONITES GUADALUPAE, Roem. 1, 416, 1849; 2, 32, 1852. A.? Waterfall at New Braunfels.

*AMMONITES INEQUIPLICATUS, Shum. 2, 591, 1860. F.? Garnet's Bluff on Red river, Fannin county. Associated with *A. swallovii* and *A. meekianus*.

Ammonites (*Placenticeras*) *lenticulare*, Meek 2, 475, 1876. See *A. pleurisepta*, Con.

AMMONITES LEONENSIS, Con. 2, 160, 1857. W. Occurs throughout extent of Washita at Fort Worth, Salado, Austin, and other localities.

AMMONITES MARCIANA, Shum. 1, 183, 1854. Cross Timbers, Texas.

Species poorly defined and figured, and locality indefinite. Of doubtful value.

*AMMONITES MEEKIANUS, Shum. 2, 592, 1860. W.? Near Post Oak creek, Grayson county. Associated with *A. swallovii*.

AMMONITES, of *noricus* type, Hill. T. Differs from *A. cordiformis* (Meek and Hayden, "Paleontology of the Upper Missouri," p. 122), by its flattened keel.

An abundant species in the arenaceous beds at the base of the Comanche series, Cow creek beds, near Travis Peak.

AMMONITES PEDERNALIS, Von Buch, Roem. 1, 418, 1849; 2, 37, 1852. F. Fredericksburg.

Ammonites pedernalis, Brinkhorst 1, not Von Buch. This is *A. pleurisepta*, Con.

AMMONITES PERUVIANUS, Von Buch, Marcou 1, 34, 1858. F. Elm Fork of Trinity, Fort Worth.

AMMONITES (PLACENTICERAS) PLACENTA, De Kay, Meek 2, 468, 1876. G.? Meek reports this species from Texas in his "Invertebrate Paleontology," without giving specific locality or horizon.

AMMONITES PLEURISEPTA, Con. 2, 159, 1857. Jacun, 3 miles below Laredo; also at Eagle Pass and other points.

This species has been confused with *A. pedernalis*, Roem., and with *A. lenticulare* by Meek.

AMMONITES SHUMARDI, Marcou 1, 33, 1858. W.? Near Denison, Texas.

AMMONITES SWALLOVII, Shum. 2, 591, 1860. N.? Four and one-half miles north of Sherman, Grayson county. Also, bluffs of Red River in Fannin and Lamar counties. Fig. in White 2.

Ammonites texanus, Roem. 1, 417, 1849; 2, 31, 1852. A. Waterfall, New Braunfels. Also at Austin. Same as *A. vespertinus*, Mort.

AMMONITES (MORTONICERAS) VESPERTINUS, Mort. 1, 40, 1834, pl. xvii, fig. 1. A. Plains of Kiamesha, I. T. Characteristic ammonite of Austin chalk. Beautifully figured in Roem. 2 under name of *A. texanus*. This species is the type of Meek's genus *Mortoniceras*, and I am inclined to think it identical with his *M. shoshonense*.

Mortoniceras shoshonense, Meek, Schlueter. F.B.? See remarks on preceding species.

AMMONITES WALCOTTI, Hill (not Sowerby). T. Murfreesboro, Ark.

AMMONITES (PRIONOCYCLUS) WOOLGARI, Mant. F.B. Smith's Branch, Texas. From near Heliotes, Bexar county, White. Ward's and Howell's College collection of Paleontology, Rochester, N. Y., 1882. Also, White 2?

ANCYLOCERAS? ANNULATUS, Shum. 2, 595, 1860. F.B.? Shawnee creek, Grayson county, in nodules of clay iron stone imbedded in indurated marly clay near base of Lower (Upper) Cretaceous. Fig. in White 2.

HAMITES FREMONTI, Marcou 1, 36, 1858. W.? Preston, on Red river, due north of Denison. I think I have collected the same species west of Fort Worth.

*HAMITES LARVATUS, Con. 1, 265, 1865. F.B.? Dallas county, Texas.

*HAMITES ROTUNDATUS, Con. 1, 266, 1855. F. B.? (Cast.) Dallas county.

*PTYCHOCERAS TEXANUS, Shum. 3, 190, 1862. N. Near Chatfield Point and Corsicana, Navarro county.

TURRILITES BRAZOENSIS, Roem. 1, 415, 1849; 2, 37, 1852. W. Brazos river, thirty miles above Torrey's trading house. Characteristic of the Washita limestone from Denison to Heliotes.

*TURRILITES HELLICINUS, Shum. 3, 191, 1862. N. Chatfield Point and Corscana, Navarro county, Texas. Associated with *Turrilites splendidus*.

TURRILITES IRRIDENS, Schluet. "Austin, Texas." F.B.? I have not seen this species, and the locality as given is indefinite, as all the horizons of the Cretaceous are within a short distance of Austin.

*TURRILITES SPLENDIDUS, Shum. 3, 191, 1862. N. Chatfield Point, Navarro county.

TURRILITES TRIDENS, Schluet. F.B.?

TURRILITES VARIANS, Schluet. 1. F.B.? "Austin, Texas."

*HELIOCERAS NAVARROENSIS, Shum. 3, 190. 1862. N. Chatfield Point, Navarro county. Associated with *Ptychoceras texanus*.

BACULITES ANCEPS, Lam., Roem., 1, 416, 1849; 2, 36, 1852. A. Waterfall, New Braunfels.

*BACULITES ANNULATUS, Con. 1, 265, 1855. N. Dallas county, Texas.

*BACULITES ASPER, Mort., Roem. 1, 416, 1849; 2, 36, 1852. A. Waterfall, New Braunfels.

BACULITES GRACILIS, Shum. 2, 596, 1860. F.B.? Shawnee creek, in Grayson county, in nodules of argillaceous iron stone with *Hamites* (*Ancyloceras*) *annulatus*.

BACULITES SPILLMANI, Con., Shum. 4, 1862. Navarro county.

BACULITES TIPPANA, Con., Shum. 4, 1862. Navarro county.

SCAPHITES SEMICOSTATUS, Roem. 2, 35, 1852. F.B. Ford of Guadalupe, New Braunfels.

SCAPHITES TEXANUS, Roem. 2, 35, 1852. F.B. Ford of Guadalupe, New Braunfels. Related to *S. vermiformis*, M. & H. See Meek 2, p. 424.

*SCAPHITES (MACROSCAPHITES) VERMICULUS, Shum. 2, 594, 1860. N. ? F.B.? Marly clay, four miles north of Sherman, Grayson county. See Meek 2, p. 419.

*SCAPHITES VERMICOSUS, Shum. 3, 189, 1862. N. Near Dresden, Navarro county. Probably same as *S. iris*, Con.; "Journal Acad. Nat. Science, Philadel.," n. s., Vol. III, pl. 25, fig. 3.

DIBRANCHIATA.

*BELEMNITELLA MUCRONATUS. G. Collected at Terrell, Texas, 1889.

CRUSTACEA.

CIRRIPEDIA.

*SCALPELLUM INEQUIPLICATUM, Shum. 3, 199, 1862. N. Chatfield Point, Navarro county.

BRACHYURA.

PARAMITHRAX ? WALKERI, Whitf., White 4, 37, 1880. A.? Near San Antonio, Texas.

GRAPTOCARCINUS TEXANUS, Roem. V. "Neues Jahrbuch Mineralogie, Geolgie, und Paleontologie," 1887; 1st Band., 2d Heft., p. 175. Shoal creek or Vola limestone, erroneously attributed to Austin chalk.

II.—Tabular View of the Stratigraphic Occurrence of the Invertebrate Fossils of the Cretaceous Formations of Texas.

Note.—All described species are given in this table without revision. For synonomy see Check List.	Lower or Comanche Series (Austin Section).									Upper or Black Prairie Series.					
	Trinity Division.	Fredericksburg Division.				Washita Division.									
	Trinity Sands.	Lower Beds.	Comanche Peak Chalk.	Caprina Limestone.	Barren Flags.	Caprotina Limestone.	Washita Limestone.	Exogyra Arietina Clays.	Shoal Creek Limestone.	Lower Cross Timbers Sands.	Eagle Ford Shales.	Austin-Dallas Chalk.	E. Ponderosa Marls.	Navarro Beds.	Glauconitic Beds.
PROTOZOA.															
Nodosaria texana, Con							x								
Orbitulites (Tinoporus) texanus, Roem			x												
Textularia, sp. ind.												x			
Globigerina, sp. ind												x			
COELENTERATA. ANTHOZOA.															
Trochocyathus (Turbinolia) texanus, Con.															
Cladophyllia furcifera, Roem.				x											
Isastrea discoidea, White											x?			x	
Coelosmilia americana, Roem				x											
Parasmilia austinensis, Roem				x											
Pleurocora coalescens, Roem				x											
Pleurocora texana, Roem									x						
Astrocoenia guadalupae, Roem															
ECHINODERMATA.															
Ophioderma, sp. nov.								x?							
Cidaris hemigranosus, Shum							x								
Salenia mexicana, Schluet												x?			
Hemicidaris, sp. ind						x									
Diadema texana, Roem			x												

II.—Tabular View of the Stratigraphic Occurrence of the Invertebrate Fossils of the Cretaceous Formations of Texas.

(CONTINUED.)

	Lower or Comanche Series (Austin Section).									Upper or Black Prairie Series.					
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Cyphosoma texana, Roem.			x												
Holectypus planatus, Roem.			x				x								
Pyrina parryi, Hall.															
Cassidulus aequoreus, Shum.												x			
Galerites (Discoidea) sp. nov.							x								
Holaster comanchesi, Marcou.							x?								
Holaster simplex, Shum.							x								
Toxaster texana, Roem.			x												
Macraster texanus, Roem.							x								
Hemiaster (Macraster?) elegans, Shum.							x								
Toxaster elegans, Shum., Con.							x								
Hemiaster parastatus, Shum.												x			
Hemiaster? texanus, Roem.												x			
MOLLUSCOIDEA.															
Eschara, sp. ind.	x		x												
Lingula, sp. ind.											x?				
Terebratulina guadalupae, Roem.												x			
Terebratula choctawensis, Shum.							x								
Terebratula leonenis, Con.							x								

II.—Tabular View of the Stratigraphic Occurrence of the Invertebrate Fossils of the Cretaceous Formations of Texas.

(CONTINUED.)

	Lower or Comanche Series (Austin Section).									Upper or Black Prairie Series.					
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Terebratula wacoensis, Roem.							x								
MOLLUSCA.															
LAMELLIBRANCHIATA.															
Ostreidae.															
Ostrea anomiæformis, Roem.												x			
Ostrea bella, Con.															
Ostrea congesta, Con.											x	x	x		
Ostrea cortex, Con.			x												
Ostrea franklini, Coquand	x														
Ostrea lyoni, Shum	x?														
Ostrea owenana, Shum														x	
Ostrea planovata, Shum														x	
Ostrea subspatulata, Lyell												x?			
Ostrea vellicata, Con.							x?								
Gryphæa aucella, Roem.															
Gryphæa forniculata, White.							x								
Gryphæa pitcheri, Mort.		x	x				x	x	x						
Gryphæa pitcheri, Mort., var. dilatata, Hill, not Marcou.							x								
Gryphæa washitaensis, Hill							x								

II.—Tabular View of the Stratigraphic Occurrence of the Invertebrate Fossils of the Cretaceous Formations of Texas.

(CONTINUED.)

	Lower or Comanche Series (Austin Section).									Upper or Black Prairie Series.					
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Gryphæa pitcheri, Mort., var. Navia, Hall			x						x						
Gryphæa vesicularis, Lam.												x	x	x?	x
Gryphæa vesicularis, Lam., var. aucella, Roem.												x			
Exogyra aquilla, Goldfuss							x								
Exogyra arietina, Roem								x							
Exogyra caprina, Con.								x							
Exogyra costata, Say												x?	x?	x	x
Exogyra fimbriata, Con															
Exogyra flabellata, Goldfuss		x	x			x									
Exogyra fragosa, Con.								x	x						
Exogyra læviuscula, Roem.												x			
Exogyra matheroniana, d'Orb		x	x			x									
Exogyra ponderosa, Roem												x	x	x?	x?
Gryphæa sinuata, var. americana, Marcou.							x								
Exogyra texana, Roem		x	x			x									
Exogyra walkeri, White.							x								
Exogyra winchelli, White															
Ostrea bellaplicata, Shum.											x				
Ostrea blackii, White											x				
Ostrea carinata, Lam							x								

II.—Tabular View of the Stratigraphic Occurrence of the Invertebrate Fossils of the Cretaceous Formations of Texas.
(CONTINUED.)

	Lower or Comanche Series (Austin Section).									Upper or Black Prairie Series.					
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Ostrea crenulimargo, Roem			x?				x								
Ostrea diluviana, Lam							x								
Ostrea larva, Lam												?	x	x	x
Ostrea marshii, Sow															
Ostrea quadriplicata, Shum							x								
Ostrea subovata, Shum	x		x				x		x						
Ostrea vellicata, Con							x								
ANOMIIDAE.															
Anomia, sp. ind	x										x		x		
Anomia anomiæformis, Roem												x			
Anomia argentaria, Mort															x
Anomia micronema? Meek															x
SPONDYLIDAE.															
Plicatula incongrua, Con												x			
Plicatula placunea? d'Orb?							x								
Spondylus guadalupae, Roem									x			x			
Spondylus, sp. nov.?							x								
LIMIDIDAE.															
Lima (Radula) crenulicosta, Roem							?								
Lima kimballi, Gabb			?				?								

II.—Tabular View of the Stratigraphic Occurrence of the Invertebrate Fossils of the Cretaceous Formations of Texas.
(CONTINUED.)

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Lima wacoensis, Roem			x				x	x							
Lima leonensis, Con			x				x								
PECTENIDAE.															
Pecten æquicostatus, Lam															
Pecten duplicosta, Roem			x?						x?						
Pecten (Vola) Roemeri, Hill									x						
Vola quinquecostata, Sow															x
Pecten nillsoni, Goldfuss												x			
Pecten quadricostatus? Sow			x				x								
Neithea occidentalis, Con			x				x								
Pecten texanus, Roem			x				x								
Amusium simplicum, Con													x	x?	x
Camptonectes virgatus, Nils													x		
Vola (Janira) wrightii, Shum				x?		x	x?								
AVICULIDAE.															
Avicula convexo-plana, Roem			x												
Avicula irridescens, Shum											x?				
Avicula pedernalis, Roem			x												
Avicula planiuscula, Roem											x				
Avicula? stabilitatis, White											x				

II.—Tabular View of the Stratigraphic Occurrence of the Invertebrate Fossils of the Cretaceous Formations of Texas.

(CONTINUED.)

	Lower or Comanche Series (Austin Section).									Upper or Black Prairie Series.					
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Gervillia gregaria, Shum.	....	....	....	....	....	....	....	....	....	x?	....	....	....	....	....
Aguillaria cumminsi, White	....	....	....	....	....	....	....	....	....	x	....	....	....	....	....
Gervillopsis ("Dalliaconcha!") invaginata, White	....	....	....	....	....	....	....	....	....	....	x	x	....	....	....
Inoceramus capulus, Shum.	....	....	....	....	....	....	....	....	....	....	x?	....	....	....	....
Inoceramus confertim-annulatus, Roem.	....	....	....	....	....	....	....	....	....	....	x	....	....	....	....
Inoceramus cripsii, Mant.	....	....	....	....	....	....	....	....	....	....	x?	x?	x	x	x
Inoceramus diverse-sulcatus, Roem.	....	....	....	....	....	....	....	....	....	....	....	x	....	....	....
Inoceramus exogyroides, Meek	....	....	....	....	....	....	....	....	....	....	x?	x	....	....	....
Inoceramus involutus, Sow.	....	....	....	....	....	....	....	....	....	....	x?	x	....	....	....
Inoceramus latus, Mant.	....	....	....	....	....	....	....	....	....	....	x?	x	....	....	....
Inoceramus mytiloides, Mant.	....	....	....	....	....	....	....	....	....	....	x	x	....	....	....
Inoceramus mytilopsis, Con.	....	....	....	....	....	....	....	....	....	....	x	x?	....	....	....
Inoceramus problematicus? Schloth.	....	....	....	....	....	....	....	....	....	....	x	x	....	....	....
Inoceramus striatus, Mant.	....	....	....	....	....	....	....	....	....	....	....	x	....	....	....
Inoceramus subquadratus, Schlueter	....	....	....	....	....	....	....	....	....	....	....	x	....	....	....
Inoceramus texanus, Con.	....	....	....	....	....	....	....	....	....	....	....	....	....	....	x?
Inoceramus umbonatus, Meek	....	....	....	....	....	....	....	....	....	....	....	x	....	....	....
Inoceramus undulato-plicatus, Roem.	....	....	....	....	....	....	....	....	....	....	....	x	....	....	....
Inoceramus sp. ind.	....	....	....	x	....	....	....	....	x	....	....	....	....	....	....

II.—Tabular View of the Stratigraphic Occurrence of the Invertebrate Fossils of the Cretaceous Formations of Texas.

(CONTINUED.)

	Lower or Comanche Series (Austin Section).									Upper or Black Prairie Series.					
	Trinity Division.	Fredericksburg Division.				Washita Division.									
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MYTILIDAE.															
Mytilus semiplicatus, Roem												X			
Mytilus tenuitesta, Roem.			X												
Modiola concentrica-costellata, Roem.			X												
Modiola granulato-cancellata, Roem												X			
Modiola parva, Hill															
Modiola pedernalis, Roem.			X												
PINNIDAE.															
Pinna, sp. ind., Roem.												X			
Pinna quadrangularis? Goldf., Roem															
Pinna, sp. ind., Hill.							X		X						
ARCIDAE.															
Arca gratiota, Hill	X														
Arca parva-missouriensis, Hill.	X														
Arca proutiana, Shum		X													
Arca subelongata, Con							X								
Arca, sp. ind			X												
Cucullæa millestriata, Shum.											X				
Cucullæa terminalis, Con.			X												
Cucullæa mailleana? d'Orb											X				

II.—Tabular View of the Stratigraphic Occurrence of the Invertebrate Fossils of the Cretaceous Formations of Texas.
(CONTINUED.)

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NUCULIDAE.															
Nucula bellastriata, Shum											x?				
Nucula haydeni, Shum											x?				
Nucula serriata, Shum											x?				
TRIGONIIDAE.															
Trigonia aliformis, Goldfuss											x				
Trigonia crenulata, Lam		x	x				x?								
Trigonia emoryi, Con							x								
Trigonia texana, Con							x								
Trigonia thoracica, Mort															x?
ASTARTIDAE.															
Cardita? eminula, Con			x?				x?								
Astarte lineolata, Roem											x?				
Astarte (Stearnsia) robbinsi, White							x								
Astarte texana, Con			x												
Astarte washitaensis, Shum			x?												
CRASSATELLIDAE.															
Crassatella lineata, Shum														x	
Crassatella? parvula, Shum														x?	
Crassatella subplana? Con														x	

II.—Tabular View of the Stratigraphic Occurrence of the Invertebrate Fossils of the Cretaceous Formations of Texas.

(CONTINUED.)

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CHAMIDAE.															
Diceras, sp. ind.		x?				x									
Requienia (Caprotina) bicornis, Meek		x?				x									
Requienia patagiata, White				x											
Requienia (Caprotina) texana, Roem		x		x?											
Monopleura marcida, White		x?		x											
Monopleura subtriquetra, Roem		x?		x											
Monopleura pingiuscula, White		x?		x											
Monopleura texana, Roem		x?		x											
Caprina crassifibra, Roem				x		x									
Caprina guadalupae, Roem				x											
Caprina planata, Con				x?											
Caprina occidentalis, Con				x											
Caprina texana, Roem				x		x?									
Plagioptychus ("Rudistes") cordatus, Roem				x		x?									
Ichthyosarcolithes anguis, Roem				x											
RUDISTAE.															
Radiolites austinensis, Roem												x			
Hippurites sabinae, Roem												x			
Hippurites texanus, Roem						x?	x								

II.—Tabular View of the Stratigraphic Occurrence of the Invertebrate Fossils of the Cretaceous Formations of Texas.

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LUCINIDAE.															
+Lucina acute-lineolata, Roem				x											
Lucina parvilineata, Shum														x	
Lucina sublenticularis, Shum											x?				
Fimbria striato-costata? d'Orb			x												
CARDIIDAE.															
Cardium choctawense, Shum											x				
Cardium congestum, Con															x?
Cardium mediale, Con			x												
Cardium transversale, Roem			x?												
Papyridea? (Cardium) sancti-sabae, Roem			x?						x?						
Liocardium (Pachycardium) spillmani, Con														x	x
Proctocardia (Cardium) brazoense, Shum			x												
Proctocardia (Cardium) coloradoense, Shum			x												
Proctocardia (Cardium) filosum, Con			x?												
Proctocardia (Cardium) hillanum, Sow			x				x								
Proctocardia (Cardium) multistriatum, Con			x?				x?								
Proctocardia (Cardium) texana, Con							x								
CYRENIDAE.															
Cyrena arkansaensis, Hill	x														

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(CONTINUED)

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Cyrena, sp. nov				x											
Corbicula pickensis, Hill	x														
CYPRINIDAE.															
Cyprina? sp. ind			x												
Venilia (Cyprina) laphami, Shum											x?				
Isocardia washita, Marcou											x?				
Isocardia? sp. ind			x												
VENERIDAE.															
Tapes hilgardi, Shum											x?				
Venus? sublamellosus, Shum											x?				
Venus? sp. ind			x												
Cytherea (Dione) lamarensis, Shum											x?				
Cytherea (Dione) leonensis, Con							x?								
Cytherea (Dione) texana, Con			x				x?								
Cyprimeria crassa, Meek											x				
TELLINIDAE.															
Linearia (Arcopagia) texana, Roem			x												
Linearia (Solen?) irradians, Roem			x												
Gari (Psammobia) cancellato-sculpta, Roem											x				

II.—Tabular View of the Stratigraphic Occurrence of the Invertebrate Fossils of the Cretaceous Formations of Texas.
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PAPHIIDAE.															
Tagellus ellipticum, Con.	....	....	....	....	....	....	....	....	....	....	....	....	....	x	....
SOLENIDAE.															
Solen? elegans? d'Orb, Roem.	....	....	x	....	....	....	....	....	....	....	....	....	....	....	....
PHOLADOMYIDAE.															
Pholadomya lincecumi, Shum.	....	....	....	....	....	....	....	....	....	....	....	....	....	x	....
Pholadomya pedernales, Roem.	....	....	x	....	....	....	....	....	....	....	....	....	....	....	....
Pholadomya texana, Con.	....	....	x?	x?	....	....	....	....	....	....	....	....	....	....	....
Homomya alta, Roem.	....	....	x	....	....	....	....	....	x?	....	....	....	....	....	....
Panopæa? newberryi, Shum.	....	....	x	....	....	....	....	....	....	....	....	....	....	....	....
Thracia myaeformis, White.	....	....	x	....	....	....	....	....	....	....	....	....	....	....	....
Panopæa? subparallela, Shum.	....	....	....	....	....	....	....	....	x?	....	....	....	....	....	....
Panopæa? subplicata, Shum.	....	....	....	....	....	....	....	....	....	....	....	....	....	x	....
Panopæa? texana, Shum.	....	....	x?	....	....	....	....	....	....	....	....	....	....	....	....
Panopæa? regularis, d'Orb.	....	....	x?	....	....	....	....	....	x?	....	....	....	....	....	....
Pachyma? austinensis, Shum.	....	....	....	....	....	....	x	....	....	....	....	....	....	....	....
Pachyma? (Cypricardia)? texana, Roem.	....	....	x	....	....	....	....	....	....	....	....	....	....	....	....
Pachyma? compacta, White.	....	....	x	....	....	....	x?	....	....	....	....	....	....	....	....
ANATINIDAE.															
Anatina sulcatina, Shum.	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....

II.—Tabular View of the Stratigraphic Occurrence of the Invertebrate Fossils of the Cretaceous Formations of Texas.
(CONTINUED.)

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Liopistha (Cardium?) elegantulum, Roem.												x			
MACTRIDAE.															
Mactra texana, Con.															x?
MYIDAE.															
Corbula graysonensis, Shum.											x				
Corbula tuomeyi, Shum.											x				
Corbula, sp. nov., Hill.				x											
Neaera alaeformis, Shum.											x				
PHOLADIDAE.															
Teredo, sp. ind.											x				
GASTEROPODA.															
PLEUROTOMARIIDAE.															
Pleurotomaria austinensis, Shum.							x								
PHASIANELLINAE.															
Phasianella perovata, Shum.			x				x?								
Phasianella, sp. ind., Roem.			x									x			
TROCHINAE.															
Trochus texanus, Roem.				x											
NERITIDAE.															
Neritina nebrascensis?, M. & H.	x														

II.—Tabular View of the Stratigraphic Occurrence of the Invertebrate Fossils of the Cretaceous Formations of Texas.
(CONTINUED.)

	Lower or Comanche Series (Austin Section).									Upper or Black Prairie Series.					
	Trinity Division.	Fredericksburg Division.				Washita Division.									
	Trinity Sands.	Lower Beds.	Comanche Peak Chalk.	Caprina Lime-stone.	Barren Flags.	Caprotina Lime-stone.	Washita Lime-stone.	Exogyra Arietina Clays.	Shoal Creek Lime-stone.	Lower Cross Timber Sands.	Eagle Ford Shales.	Austin-Dallas Chalk.	E. Ponderosa Marls.	Navarro Beds.	Glauconitic Beds.
Neritopsis biangulatus, Shum.	....	....	....	....	....	....	....	....	....	....	x?	....	....	....	....
SOLENIIDAE.															
Solarium planorbis	....	....	....	x	....	....	....	....	....	....	....	....	....	....	....
SCALARIDAE.															
Scalaria (Scala) bicarinifera, Shum.	....	....	....	....		....	....	....	....	....	....	x?	....	....	....
Scalaria (Scala) forsheyi, Meek.	....	....	....	....	....	....	....	....	....	....	....	....	....	x	....
Scalaria lamarensis, Shum.	....	....	....	....	....	....	....	....	....	....	x?	....	....	x?	....
Scalaria, sp. ind.	....	....	....	....	....	....	....	....	....	....	....	....	....	x	....
TURRITELLIDAE.															
Turritella corsicana, Shum.	....	....	....	....	....	....	....	....	....	....	....	....	....	x	....
Turritella irrorata, Con.	....	....	....	....	....	....	x	....	....	....	....	....	....	....	....
Turritella? leonensis, Con.	....	x	....	....	....	....	x?	....	....	....	....	....	....	....	....
Turritella marnochi, White	....	....	....	....	....	....	x	....	....	....	....	....	....	....	....
Turritella planilateris, Con.	....	....	....	....	....	....	x	....	....	....	....	....	....	....	....
Turritella seriatim-granulata, Roem.	....	....	x?	....	....	....	x?	x?	....	....	....	....	....	....	....
Turritella winchelli, Shum.	....	....	....	....	....	....	....	....	....	....	....	....	....	x	....
VERMETIDAE.															
Vermetus (Serpula), sp. ind.	x	....	x	....	....	....	x	....	x	....	x	....	....	x	x
NATICIDAE.															
Natica? (Amauropsis?) avellana, Roem.	....	....	....	x	....	....	....	....	....	....	....	....	....	....	....

II.—Tabular View of the Stratigraphic Occurrence of the Invertebrate Fossils of the Cretaceous Formations of Texas.
(CONTINUED.)

	Lower or Comanche Series (Austin Section).									Upper or Black Prairie Series.					
	Trinity Division.	Fredericksburg Division.				Washita Division.									
	Trinity Sands.	Lower Beds.	Comanche Peak Chalk.	Caprina Lime-stone.	Barren Flags.	Caprotina Lime-stone.	Washita Lime-stone.	Exogyra Arietina Clays.	Shoal Creek Lime-stone.	Lower Cross Timber Sands.	Eagle Ford Shales.	Austin-Dallas Chalk.	E. Ponderosa Marls.	Navarro Beds.	Glauconitic Beds.
Natica? collina, Con							x								
Natica? texana, Con															
Lunatia? (Natica) acutispira, Shum.			x												
Tylostoma? (Natica?) pedernalis, Roem.		x													
Tylostoma? (Natica?) prægrandis, Roem.			x												
PALUDINIDAE.															
Vivipara? cassatotensis, Hill	x														
Vivipara (Pleurocera) strombiformis, Schloth.	x														
PYRAMIDELLIDAE.															
Eulima? subfusiformis, Shum			x												
Eulima? texana, Roem												x			
Chemnitzia gloriosa, Roem.												x		x	
Chemnitzia occidentalis, Gabb.			x				x?								
Chemnitzia? (Scalaria?) texana, Meek.												x			
NERINEIDAE.															
Nerinea acus, Roem		x	x	x											
Nerinea austinensis, Roem.		x													
Nerinea cultrispira, Roem				x											
Nerinea schottii, Con				x											
Nerinea subula, Roem.				x											

II.—Tabular View of the Stratigraphic Occurrence of the Invertebrate Fossils of the Cretaceous Formations of Texas.
(CONTINUED.)

	Lower or Comanche Series (Austin Section).									Upper or Black Prairie Series.					
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Nerinea texana, Roem	....	....	x	....	....	....	....	....	....	....	....	....	....	....	....
CERITHIIDAE.															
Cerithium austinensis, Roem	....	x	....	....	....	....	....	....	....	....	....	....	....	....	....
Cerithium bosquense, Shum	....	....	x	....	....	....	....	....	....	....	....	....	....	....	....
Cerithium obliterato-granosum, Roem	....	....	....	x	....	....	....	....	....	....	....	....	....	....	....
Cerithium, sp. ind., Roem	....	....	....	....	....	....	....	....	....	....	....	x	....	....	....
APORRHAIDAE.															
Anchura (Drepanocheilus) mudgeana, White	....	....	....	....	....	....	....	....	....	....	x?	....	....	....	....
STROMBIDAE.															
Pugnellus densatus, Con	....	....	....	....	....	....	....	....	....	....	....	....	....	x	....
Rostellaria? collina, Con	....	....	x	....	....	....	....	....	....	....	....	....	....	....	....
Rostellaria monpleurophila, Roem	....	....	....	x?	....	....	....	....	....	....	....	....	....	....	....
Rostellaria, sp. ind., Roem	....	....	....	....	....	....	....	....	....	....	....	x	....	....	....
FICULIDAE.															
Ficus (Pyrifusus) granosus, Shum	....	....	....	....	....	....	....	....	....	....	....	....	x	....	....
BUCCINIDAE.															
Buccinopsis? conradi, Hill	x	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Buccinopsis? parryi, Con	....	....	x	....	....	....	....	....	....	....	....	....	....	....	....
PURPURIDAE.															
Purpura cancellaria, Shum.?	....	....	....	....	....	....	....	....	....	....	....	....	....	x	....

II.—Tabular View of the Stratigraphic Occurrence of the Invertebrate Fossils of the Cretaceous Formations of Texas.
(CONTINUED.)

	Lower or Comanche Series (Austin Section).									Upper or Black Prairie Series.					
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Rapa supraplicata, Con.	....	....	....	....	....	....	....	....	....	....	....	....	x	x	....
FUSIDAE.															
Fusus? (Turris?) pedernalis, Roem.	....	....	....	x	....	....	....	....	....	....	....	....	....	....	....
Fasciolaria, sp. ind.	....	....	....	....	....	....	....	....	....	....	....	....	....	x	....
Pyrula, sp. ind., Roem.	....	....	....	....	....	....	....	....	....	....	....	x	....	....	....
VOLUTIDAE.															
Volutilithes, navarroensis, Shum.	....	....	....	....	....	....	....	....	....	....	....	....	x	x	....
Voluta (Rostellites?) texana, Con.	....	....	....	....	....	....	....	....	....	....	....	....	....	....	x
PLEUROTOMIDAE.															
Pleurotoma? pedernalis, Roem.	....	....	x?	....	....	....	....	....	....	....	....	....	....	....	....
Pleurotoma texana, Shum.	....	....	....	....	....	....	....	....	....	....	....	....	....	x	....
Pleurotoma tippana, Con.	....	....	....	....	....	....	....	....	....	....	....	....	....	x	....
ACTAEONIDAE.															
Actaeon (Tornatella) texana, Shum.	....	....	....	....	....	....	....	....	....	....	x	....	....	....	....
Solidula riddelli, Shum.	....	....	....	....	....	....	....	....	....	....	....	....	....	x	....
Actaeonella (Volvulina) dolium, Roem.	....	....	x	....	....	....	....	....	....	....	....	....	....	....	....
Cinulia (Ringinella) acutispira, Shum.	....	....	....	....	....	....	....	....	....	....	x?	....	....	....	....
Cinulia (Ringinella) pulchella, Shum.	....	....	....	....	....	....	....	....	....	....	....	....	....	x	....
Cinulia (Avellana) subpellucida, Shum.	....	....	....	....	....	....	....	....	....	....	x?	....	....	x?	....
Cinulia (Avellana) texana, Shum.	....	....	x	....	....	....	....	....	....	....	....	....	....	....	....

II.—Tabular View of the Stratigraphic Occurrence of the Invertebrate Fossils of the Cretaceous Formations of Texas.

(CONTINUED.)

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BULLIDAE.															
Globiconcha? coniformis, Roem.			x												
Globiconcha? elevata, Shum.			x												
Globiconcha? planata, Roem				x?			x?								
Globiconcha? (Tylostoma?) tumida, Shum.			x?												
Globiconcha?, sp. nov.									x						
Cylichna minuscula, Shum.														x?	
Cylichna (Bulla), sp. ind												x			
Cylichna secalina, Shum.														x	
Cylichna striatella, Shum.														x	
SIPHONARIIDAE.															
Anisomyon haydeni, Shum.														x	
Anisomyon, sp. ind.												x			
CEPHALOPODA.															
NAUTILOIDEA.															
Nautilus dekayi?, Mort.												x		x	x
Nautilus, elegans, Sow.									x?			x?			
Nautilus simplex, Sow., Roem.												x			
Nautilus texanus, Shum.							x		x?						

II.—Tabular View of the Stratigraphic Occurrence of the Invertebrate Fossils of the Cretaceous Formations of Texas.
(CONTINUED.)

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AMMONOIDEA.															
Ammonites acuto-carinatus, Shum			x												
Ammonites belknapii, Marcou							x								
Ammonites brazoensis, Shum							x								
Ammonites dentato-carinatus, Roem												x			
Ammonites flaccidicosta, Roem											x				
Ammonites geniculatus, Con							x								
Ammonites gibbonianus, Lea			x?				x								
Ammonites graysonensis, Shum											x?				
Ammonites guadalupae, Roem												x?			
Ammonites inequiplicatus, Shum			x?												
Ammonites (Placenticeras) lenticulare, Meek			x?												x
Ammonites leonensis, Con							x								
Ammonites marciana, Shum							x								
Ammonites meekianus, Shum											x				
Ammonites, noricus type, Hill	x														
Ammonites pedernalis, Von Buch			x												
Ammonites pedernalis, Brinkhorst															x
Ammonites peruvianus, Von Buch			x?												
Ammonites (Placenticeras) placenta, DeKay															x?

II.—Tabular View of the Stratigraphic Occurrence of the Invertebrate Fossils of the Cretaceous Formations of Texas.

(CONTINUED.)

	Lower or Comanche Series (Austin Section).									Upper or Black Prairie Series.					
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Ammonites pleurisepta, Con															x
Ammonites shumardi, Marcou							x?								
Ammonites swallovii, Shum											x?				
Ammonites texanus, Roem												x			
Ammonites (Mortoniceras) vespertinus, Mort												x			
Mortoniceras shoshonense, Meek											x?	x			
Ammonites walcottii, Hill, not Sowerby	x														
Ammonites (Prionocyclus) woolgari, Mant											x				
Ancyloceras? annulatus, Shum											x?				
Hamites fremonti, Marcou							x?								
Hamites larvatus, Con											x?				
Hamites rotundatus, Con											x?				
Ptychoceras texanus, Shum														x	
Turrilites brazoensis, Roem							x								
Turrilites hellicinus, Shum														x	
Turrilites irridens, Schluet											x?				
Turrilites splendidus, Shum														x	
Turrilites tridens, Schluet											x?				
Turrilites varians, Schluet											x?				
Helioceras navarroensis, Shum														x	

II.—Tabular View of the Stratigraphic Occurrence of the Invertebrate Fossils of the Cretaceous Formations of Texas.
(CONTINUED.)

	Lower or Comanche Series (Austin Section).									Upper or Black Prairie Series.					
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Baculites anceps, Lam.												x			
Baculites annulatus, Con.														x	
Baculites asper, Mort.												x			
Baculites gracilis, Con.														x	
Baculites spillmani, Con., Shum.											x?				
Baculites tippaensis, Con.														x	
Scaphites semicostatus, Roem.											x				
Scaphites texanus, Roem.											x				
Scaphites (Macroscaphites) vermiculus, Shum.											x?			x?	
Scaphites vermicosus, Shum.														x	
DIBRANCHIATA.															
Belemnitella mucronatus.															x
CRUSTACEA.															
CIRRIPEDIA.															
Scalpellum inequiplicatum, Shum.														x	
BRACHYURA.															
Paramithrax? walkeri, Whitf.												x?			
Graptocarcinus texanus, Roem.									x						

LISTS OF FAUNAS.

FAUNAS OF THE VARIOUS HORIZONS OF THE TWO CRETACEOUS FORMATIONS OF TEXAS.

All species are given. For revision see Check List.

A dagger (†) indicates those species which are doubtfully referred to the horizon in question.

A.—COMANCHE SERIES.

FAUNA OF TRINITY SANDS.

Eschara, sp. ind.
Ostrea franklini, Coquand.
Ostrea lyoni,† Shumard.
Ostrea subovata, Shum.
Anomia, sp. ind.
Arca gratiota, Hill.
Arca parva-missouriensis, Hill.
Arca proutiana,† Shum.
Cyrena arkansaensis, Hill.
Corbicula pikensis, Hill.
Neritina nebrascensis? M. and H.
Vermetus (*Serpula*), sp. ind.
Vivipara? cassatotensis, Hill.
Pleurocera strombiformis, Schloth.
Buccinopsis? conradi, Hill.
Ammonites, noricus type, Hill.
Ammonites walcottii, Hill, not Sow.

And unstudied forms.

FAUNA OF LOWER OR FREDERICKSBURG DIVISION.

COMANCHE PEAK AND ALTERNATING BEDS.

Orbitulites (*Tinoporus*) *texanus*, Roem.
Diadema texana, Roem.
Cyphosoma texana, Roem.
Holectypus planatus, Roem.
Toxaster texana, Roem.
Eschara, sp. ind.
Ostrea cortex, Con.
Gryphœa calceola, Quencedt, M. and H.
Gryphœa pitcheri, Mort.
Gryphœa pitcheri, Mort. *var. Navia*, Hall.
Exogyra flabellata, Goldfuss.
Exogyra matheroniana, d'Orb.
Exogyra texana, Roem.
Ostrea crenulimargo,† Roem.
Ostrea subovata, Shum.
Cyprina? sp. ind.
Isocardia? sp. ind.
Cypricardia texana, Roem.
Venus? sp. ind.
Cytherea (*Dione*) *texana*, Con.
Linearia (*Arcopagia*) *texana*, Roem.
Linearia (*Solen?*) *irradians*, Roem.
Solen? elegans, d'Orb.
Pholadomya pedernalis, Roem.
Pholadomya texana,† Con.
Homomya alta, Roem.
Panopœa? newberryi, Shum.
Thracia myœformis, White.
Panopœa? texana,† Shum.
Panopœa? regularis,† d'Orb.

Lima kimballi,† Gabb.
Lima wacoensis, Roem.
Lima leonensis, Con.
Pecten duplicosta,† Roem.
Pecten quadricostatus? Sow.
Neithea occidentalis, Con.
Pecten texanus, Roem.
Avicula convexo-plana, Roem.
Avicula pedernalis, Roem.
Mytilus tenuitesta, Roem.
Modiola concentrica-costellata, Roem.
Modiola pedernalis, Roem.
Arca, sp. ind.
Cucullæa terminalis, Con.
Trigonia crenulata, Lam.
Cardita? eminula,† Con.
Astarte texana, Con.
Astarte washitaensis,† Shum.
Diceras,† sp. ind.
Monopleura, sp. ind.
Requienia (*Caprotina*) *texana*, Roem.
Fimbria striato-costata? d'Orb.
Arcopagia texana, Roem.
Corbis, sp. ind.
Cardium mediale, Con.
Cardium transversale,† Roem.
Papyridea? (*Cardium*) *sancti-sabæ,*† Roem.
Protocardia (*Cardium*) *brazoense*, Shum.
Protocardia (*Cardium*) *coloradoense*, Shum.
Protocardia (*Cardium*) *filosum,*† Con.
Protocardia (*Cardium*) *hillanum*, Sow.
Protocardia (*Cardium*) *multistriatum,*† Con.
Pachyma? (*Cypricardia?*) *texana*, Roem.
Pachyma? compacta, White.
Pinna, sp. ind,
Phasianella perovata, Shum.
Phasianella, sp. ind., Roem.
Turritella seriatim-granulata,† Roem.
Vermetus (*Serpula*), sp. ind.
Lunatia? (*Natica*) *acutispira*, Shum.
Tylostoma? (*Natica?*) *pedernalis*, Roem.
Tylostoma? (*Natica?*) *praegrandis*, Roem.
Eulima? subfusiformis, Shum.
Chemnitzia occidentalis, Gabb.
Nerinea acus, Roem.
Nerinea texana, Roem.
Cerithium austinensis, Roem.
Cerithium bosquense, Shum.
Rostellaria? callira, Con.
Buccinopsis? parryi, Con.
Pleurotoma? pedernalis,† Roem.
Actaeonella (*Volvulina*) *dolium*, Roem.
Cinulia (*avellana*) *texana*, Shum.
Globiconcha? coniformis, Roem.
Globiconcha? elevata, Shum.
Globiconcha? (*Tylostoma?*) *tutrida,*† Shum.
Fusus pedernalis, Roem.
Ammonites acuto-carniatus, Shum.
Ammonites gibbonianus,† Lea.
Ammonites inequiplicatus,† Shum.
Ammonites pedernalis, Von Buch.
Ammoniets peruvianus, Von Buch.

FAUNA OF CAPRINA LIMESTONE.

Cladophyllia furcifera,† Roem.
Coelosmilia americana, Roem.
Parasmilia austinensis.
Pleurocora coalescens, Roem.
Hippurites texanus,† Roem.
Lucina acute-lineolata, Roem.
Cyrena, sp. nov.
Pholadomya texana,† Con.

Vola (*Janira*) *wrightii*, Shum.
Requienia patagiata, White.
Requienia (*Caprotina*) *texana*, Roem.
Monopleura marcida, White.
Monopleura subtriquetra, Roem.
Monopleura pinguiscula, White.
Monopleura texana, Roem.
Caprina crassifibra, Roem.
Caprina guadalupae, Roem.
Caprina planata,† Con.
Caprina texana, Roem.
Plagioptychus ("*Rudistes*") *cordatus*, Roem.
Ichthyosarcolithes anguis, Roem.
Corbula, sp. nov., Hill.
Trochus texanus, Roem.
Solarium planorbis.
Natica? (*Amauropsis*?) *avellana*, Roem.
Nerinea acus, Roem.
Nerinea austinensis, Roem.
Nerinea cultrispira, Roem.
Nerinea schottii, Con.
Nerinea subula, Roem.
Cerithium obliterato-granosum, Roem.
Rostellaria monpleurophila,† Roem.
Fusus? (*Turris*?) *pedernalis*, Roem.
Globiconcha? *planata*,† Roem.

FAUNA OF CAPROTINA LIMESTONE.

Hemicidaris, sp. ind.
Exogyra flabellata, Goldfuss.
Exogyra matheroniana, d'Orb.
Exogyra texana, Roem.
Vola (*Janira*) *wrightii*, Shum.
Diceras, sp. ind.
Requienia (*Caprotina*) *bicornis*, Meek.
Requienia (*Caprotina*) *texana*, Roem.
Caprina crassifibra, Roem.
Caprina texana,† Roem.
Plagioptychus ("*Rudistes*") *cordatus*,† Roem.
Hippurites texanus, Roem.
Nerinea, sp. nov.

FAUNA OF WASHITA DIVISION.

WASHITA LIMESTONE SUBDIVISION.

Nodosaria texana, Con.
Cidaris hemigranosus, Shum.
Holectypus planatus, Roem.
Galerites (*Discoidea*), sp. nov.
Holaster comanchesi,† Marcou.
Holaster simplex, Shum.
Macraster texanus, Roem.
Hemiaster (*Macraster*?) *elegans*, Shum.
Toxaster elegans, Shum., Con.
Terebratula choctawensis, Shum.
Terebratula leonensis, Con.
Terebratula wacoensis, Roem.
Ostrea vellicata,† Con.
Gryphæa forniculata,† White.
Gryphæa pitcheri, Mort.
Arca subelongata, Con.
Trigonia crenulata,† Lam.
Trigonia emoryi, Con.
Trigonia texana, Con.
Cardita? *eminula*,† Con.
Astarte (*Sternsia*) *robbinsi*, White.
Protocardia (*Cardium*) *hillanum*, Sow.
Protocardia (*Cardium*) *multistriatum*,† Con.
Protocardia (*Cardium*) *texana*, Con.
Cytherea (*Dione*) *leonensis*,† Con.
Cytherea (*Dione*) *texana*,† Con.
Pachyma? *austinensis*, Shum.
Pachyma? *compacta*,† White.
Pleurotomaria austinensis, Shum.

Gryphæa pitcheri, Mort. *var. dilatata*, Hill. Same as next.
Gryphæa washitaensis, Hill.
Exogyra aquilla, Goldfuss.
Gryphæa sinuata var. americana, Marcou.
Exogyra walkeri, White.
Ostrea carinata, Lam.
Ostrea crenulimargo,† Roem.
Ostrea subovata, Shum.
Ostrea vellicata, Con.
Plicatula placunea? d'Orb?
Spondylus, sp. nov?
Lima kimballi,† Gabb.
Lima wacoensis, Roem.
Lima leonensis, Con.
Pecten quadricostatus, Sow.
Neithea occidentalis, Con.
Pecten texanus, Roem.
Vola (Janira) wrightii,† Shum.
Pinna, sp. ind., Hill.
Phasianella perovata,† Shum.
Turritella irrorata, Con.
Turritella marnochi, White.
Turritella planilateris, Con.
Turritella seriatim-granulata,† Roem.
Vermetus (Serpula), sp. ind.
Natica? collina, Con.
Chemnitzia occidentalis,† Gabb.
Globiconcha? planata,† Roem.
Nautilus texanus, Shum.
Cephalopod (genus indeterminate) texanus, Hill.
Ammonites belknapii, Marcou.
Ammonites brazoensis, Shum.
Ammonites geniculatus, Con.
Ammonites gibbonianus, Lea.
Ammonites leonensis, Con.
Ammonites marciana, Shum.
Ammonites shumardi,† Marcou.
Hamites fremonti, Marcou.
Turrilites brazoensis, Roemer.

FAUNA OF EXOGYRA ARIETINA CLAYS.

Ophioderma, sp. nov.†
Holectypus, sp. nov.
Gryphæa pitcheri, Mort.
Exogyra arietina, Roem.
Exogyra caprina, Con.
Neithea quadricostatus, Roem.
Turritella, sp. nov.

FAUNA OF SHOAL CREEK LIMESTONE.

Gryphæa pitcheri, *Mort. var. naria*, Hall. (at base only.)
Exogyra fragosa, Con.
Ostrea subovata, Shum.
Pecten (Vola) roemeri, Hill.
Papyridea? (Cardium) sancti-sabæ,† Roem.
Panopæa? regularis,† d'Orb.
Panopæa subparallela,† Shum.
Vermetus (serpula) sp. ind.
Globiconcha? sp. nov.
Nautilus texanus,† Shum.
Ammonites, sp. ind.
Cerithium, sp. ind.
Turritella, sp. ind.
Glycimeris, sp. ind.
Pinna, sp. ind.
Echinodermata.
Foraminiferæ.

FAUNA OF THE DENISON BEDS.*

Ostrea quadriplicata, Shum.
Inoceramus, nov. sp.
Inoceramus capulus.
Corbula tuomeyi.
Corbula graysonesis, Shum.
Panopæa subparallela, Shum.
Nucula haydeni.
Gervillia gregaria.
Tapes hilgardi.
Cytherea lamarensis.
Turitella, sp. ind.
Ammonites graysonesis, Shum.
Ammonites inequiplicatus, Shum.
Ammonites meekianus, Shum.
Ammonetes swallovii, Shum.
Ancyloceras annulatus, Shum.
Baculites gracilus, Con.
Scaphites vermiculus, Shum.

B.—UPPER OR BLACK PRAIRIE SERIES.

FAUNA OF LOWER CROSS TIMBER SANDS.

Gervillia gregaria, Shum.
Aguillaria cumminsi, White.
Turritella, sp. ind.
Ammonites, sp. ind.
Scaphites, sp. ind.
Cerithium, sp. ind.
Ostrea, sp. ind.
Corbicula, sp. ind.
Arbacia, sp. ind.
Teredo, sp. ind.
Neritina, sp. ind.

FAUNA OF EAGLE FORD SHALES.

Isastrea discoidea,† White.
Lingula,† sp. ind.
Ostrea congesta, Con.
Ostrea bellaplicata, Shum.
Ostrea blackii, White.
Exogyra columbella, Meek.
Anomia, sp. ind.
Lima (Radula?) crenulicosta,† Roem.
Avicula irridescens, Shum.
Avicula planiuscula, Roem.
Avicula?? stabilitatis,† White.
Gervillopsis ("Dalliaconcha"!) invaginata, White.
Inoceramus capulus,† Shum.
Inoceramus confertim-annulatus, Roem.
Inoceramus cripsii,† Mant.
Inoceramus exogyroides,† Meek.
Inoceramus involutus,† Sow.
Inoceramus latus,† Mant.
Cyprimeria crassa, Meek.
Gari (Psammobia) cancellato-sculpta, Roem.
Corbula graysonensis,† Shum.
Corbula tuomeyi, Shum.
Neaera aliformis, Shum.
Teredo, sp. ind.
Neritopsis biangulatus,† Shum.
Scalaria lamarensis,† Shum.
Natica, sp. ind.
Vermetus (Serpula), sp. ind.
Anchura (Drepanocheilus) mudgeana,† White.
Aetaeon (Tornatella) texana, Shum.
Cinulia (Ringinella) acutispira,† Shum.
Cinulia (Avellana) subpellucida,† Shum.
Ammonites flaccidicosta, Roem.

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*These beds succeed the Washita limestone from Fort Worth northward. Some of these forms have been questionably placed in the Eagle Ford shales in the tables. These are quoted from Shumard, "Trans. Acad. Sci. of St. Louis," Vol. I.

Inoceramus mytiloides, Mant.
Inoceramus mytilopsis, Con.
Inoceramus problematicus? Schloth.
Cucullæa millestriata, Shum.
Cucullæa mailleana? d'Orb.
Nucula bellastriata,† Shum.
Nucula haydeni,† Shum.
Nucula serriata,† Shum.
Trigonia aliformis, Goldfuss.
Astarte lineolata,† Roem.
Lucina sublenticularis,† Shum.
Cardium choctawense, Shum.
Venilia (*Cyprina*) *laphami*,† Shum.
Isocardia washita,† Marcou.
Tapes hilgardi,† Shum.
Venus? sublamellosus,† Shum.
Cytherea (*Dione*) *lamarensis*,† Shum.
Ammonites graysonensis,† Shum.
Ammonites meekianus, Shum.
Ammonites swallovii,† Shum.
Mortoniceras shoshonese,† Meek.
Ammonites (*Prionocyclus*) *woolgari*,† Mant.
Ancyloceras? annulatus,† Shum.
Hamites larvatus,† Con.
Hamites rotundatus,† Con.
Turrilites irridens,† Schluet.
Turrilites tridens,† Schluet.
Turrilites varians,† Schluet.
Scaphites texanus, Roem.
Scaphites semicostatus, Roem.
Scaphites (*Macroscaphites*) *vermiculus*,† Shum.

FAUNA OF AUSTIN-DALLAS CHALK.

Textularia, sp. ind.
Globigerina, sp. ind.
Cassidulus aequoreus, Shum.
Hemiaster parastatus, Shum.
Hemiaster? texanus, Roem.
Terebratulina guadalupae, Roem.
Ostrea anomiæformis, Roem.
Ostrea congesta, Con.
Ostrea subspatula,† Lyell.
Gryphæa vesicularis, Lam.
Gryphæa vesicularis, Lam., *var. Aucella*, Roem.
Exogyra columbella, Meek.
Exogyra costata,† Say.
Exogyra læviuscula, Roem.
Exogyra ponderosa, Roem.
Ostrea larva,† Lam.
Anomia anomiæformis, Roem.
Spondylus guadalupae, Roem.
Pecten nillsoni, Goldfuss.
Arca, sp. ind.
Gervillopsis ("*Dalliaconcha*") *invaginata*, White.
Inoceramus undulato-plicatus, Roem.
Mytilus semiplicatus, Roem.
Modiola, sp. ind., Roem.
Pinna, sp. ind., Roem.
Radiolites austinensis, Roem.
Radiolites sabinae, Roem.
Radiolites austinensis, Roem.
Psammobia cancellato-sculpta, Roem.
Liopistha (*Cardium ?*) *elegantulum*, Roem.
Phasianella, sp. ind., Roem.
Scalaria texana, Roem.
Scalaria (*Scala*) *bicarinifera*,† Shum.
Rostellaria, sp. ind.
Eulima? texana, Roem.
Chemnitzia gloriosa, Roem.
Chemnitzia? (*Scalaria?*) *texana*, Meek.
Cerithium, sp. ind., Roem.
Pyrula, sp. ind.
Cylichna (*Bulla*), sp. ind.
Anisomyon, sp. ind.
Nautilus dekayi? Mort.
Nautilus elegans, Sow.

Inoceramus cripsii,† Mant.
Inoceramus diverse-sulcatus, Roem.
Inoceramus exogyroides, Meek.
Inoceramus involutus, Sow.
Inoceramus latus, Mant.
Inoceramus mytiloides, Mant.
Inoceramus mytilopsis,† Con.
Inoceramus problematicus?† Schloth.
Inoceramus striatus, Mant.
Inoceramus subquadratus, Schlueter.
Inoceramus umbonatus, Meek.
Nautilus simplex, Sow., Roem.
Ammonites dentato-carinatus, Roem.
Ammonites guadalupae,† Roem.
Ammonites texanus, Roem.
Ammonites (Mortoniceras) vespertinus, Mort.
Mortoniceras shoshonense, Meek.
Baculites anceps, Lam.
Baculites asper, Mort.
Paramithrax? walkeri,† Whitf.

FAUNA OF EXOGYRA PONDEROSA MARLS.

Ostrea congesta, Con.
Gryphœa vesicularis, Lam.
Exogyra costata,† Say.
Exogyra ponderosa, Roem.
Ostrea larva, Lam.
Anomia, sp. ind.
Amusium simplicum, Con.
Camptonectes virgatus, Nils.
Inoceramus cripsii, Mant.
Ficus (Pyrifusus) granosus, Shum.
Baculites, sp. ind.

FAUNA OF NAVARRO BEDS, OR UPPER FOSSILIFEROUS HORIZON OF THE PONDEROSA MARLS.

Isastrea discoidea, White.
Ostrea owenana, Shum.
Ostrea planovata, Shum.
Gryphœa vesicularis,† Lam.
Exogyra costata, Say.
Exogyra ponderosa,† Roem.
Ostrea larva, Lam.
Pecten simplicus.
Pecton burlingtonensis.
Inoceramus cripsii, Mant.
Crassatella lineata, Shum.
Crassatella? parvula,† Shum.
Crassatella subplana? Con.
Lucina parvilineata, Shum.
Liocardium (Pachycardium) spillmani, Con.
Tagelus (Legumen) ellipticum, Con.
Tagelus (Siliquaria) biplicata.
Pholadomya elegantula.
Pholadomya lincecumi, Shum.
Chemnitzia gloriosa, Roem.
Pugnellus densatus, Con.
Purpura cancellaria, Shum.?
Rapa supraplicata, Con.
Fasciolaria, sp. ind.
Volutilithes navarroensis, Shum.
Pleurotoma rippleyana.
Pleurotoma texana, Shum.
Pleurotoma tippana, Con.
Solidula riddelli, Shum.
Cinulia (Ringinella) pulchella, Shum.
Cinulia (Avellana) subpellucida, † Shum.
Cylichna minuscula,† Shum.
Cylichna secalina, Shum.
Cylichna striatella,† Shum.
Anisomyon haydeni, Shum.
Nautilus dekayi? Mort.
Ptychoceras texanus, Shum.
Turrilites helicinus, Shum.

Pholadomya tippana, Shum.
Panopæa? subplicata, Shum.
Anatina sulcatina, Shum.
Scalaria (Scala) forsheyi, Meek.
Scalaria lamarensis,† Shum.
Scalaria, sp. ind.
Turritella corsicana, Shum.
Turritella winchelli, Shum.
Turritella tippana, Con.
Ficus subdensatus.
Vermetus (Serpula), sp. ind.
Turrilites splendidus, Shum.
Helioceras navarroensis, Shum.
Baculites annulatus, Con.
Baculites gracilis, Con.
Baculites spillmani.
Baculites tippaensis, Con.
Scaphites (Macroscaphites) vermiculus,† Shum.
Scaphites vermicosus, Shum.
Scalpellum inequiplicatum, Shum.

FAUNA OF THE GLAUCONITIC BEDS.*

Gryphæa vesicularis, Lam.
Exogyra costata, Say.
Exogyra ponderosa,† Roem.
Ostrea larva, Lam.
Anomia argentaria, Mort.
Amusium simplicum, Con.
Inoceramus cripsii, Mant.
Inoceramus texanus,† Con.
Trigonia thoracica,† Mort.
Liocardium (Pachycardium) spillmani, Con.
Vermetus (Serpula), sp. ind.
Voluta (Rostellites?) texana, Con.
Nautilus dekayi, Mort.
Ammonites pedernalis, Binkhorst, not Von Buch.
Ammonites (Placenticeras) placenta,† Dekay.
Ammonites pleurisepta, Con.
Belemintella micronatus, Meek.

*This division has been least studied of all the Texas beds, and hence this list does not at all approximate completeness.

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